LRFD

Section 2.4

Revised: **May 2006**

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2.4.1 Vertical and Horizontal Clearance (**)

1.1 Vertical Clearance (***)

Highway Grade Separation

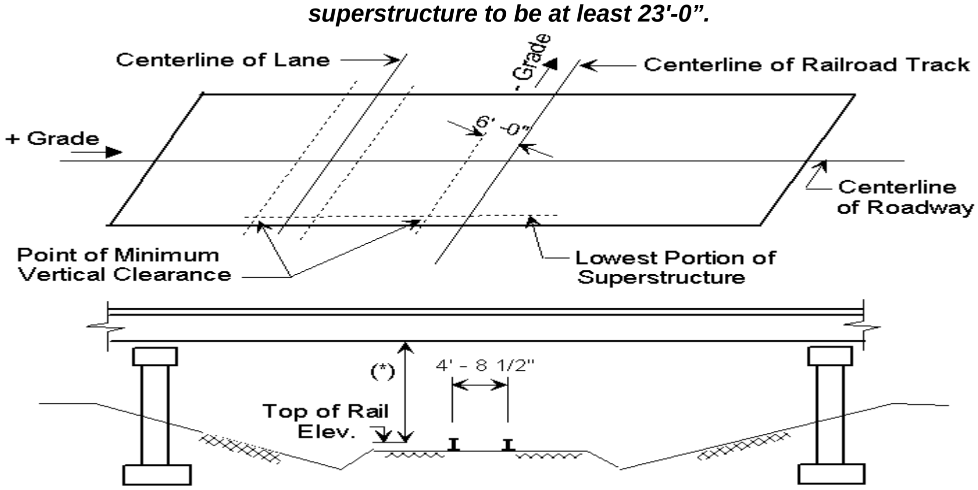
The minimum vertical clearance for highway grade separations shall be the distance from the lowest point (including splice plate and bolt heads) on the bridge superstructure (including deflection from dead load and live load plus impact) to the highest point on existing lane or shoulder. The actual minimum vertical clearance for each roadway underneath the bridge shall be shown on the front sheet of the bridge plans.

Railroad Grade Separation

The minimum vertical clearance for railroad grade separations shall be the distance from the lowest point (including splice plate and bolt heads) on the bridge superstructure (including deflection from dead load and live load plus impact) to the elevation of the top of the highest rail at a point on a line 6'-0" from and parallel to the centerline of the track. If the track is superelevated, the superelevation slope shall continue to the point 6'-0" from the track centerline. An elevation shall be given on the design plans at the top of the highest rail directly on line with the point of minimum vertical clearance.

Use an asterisk and the corresponding note *(*)*, to designate the vertical clearance for a railroad grade separation. Detail vertical clearance as shown in Figure 2.4.1.1 and place the following note on the plans near the elevation on the front sheet.

(*) Final Vertical clearance from top of rails to bottom of superstructure to be at least 23'-0".



(*) Indicates vertical clearance dimension and a note.

Figure 2.4.1.1 Vertical Clearance

(**) For traffic maintained under the structure during construction, see Office Notes Section for proper clearance notes.
(***) See the Design Layout for minimum clearance.

Minimum Vertical Clearances for Grade Separation Structures

Table 2.4.1.1 MoDOT Design Division Project Development Manual Table 5-04.1

Facility Under Structure	Clearance	Remarks
Interstate and Principal Arterial Routes	16'-6"	Includes shoulders
Other State Routes - Over 1700 VPD	16'-6"	Includes shoulders
(*) State Routes - Under 1700 VPD	15'-6"	Includes shoulders
(*) Other streets and roads	14'-6" (*)	Does not include shoulders
Railroads	23'-0"	Absolute minimum 23'-0"

(*) To provide continuity of travel for taller vehicles exceptions can be made both rural and urban for any routes connecting to the systems where taller vehicles are allowed but not to exceed 16’-6”. A minimum vertical clearance of 15’-6” is required for bridges located in commercial zones.

1.2 Horizontal Clearance (**)

Minimum Horizontal Clearances for Grade Separation Structures

Table 2.4.1.2 MoDOT Design Division Project Development Manual Table 5-04.2

Facility Under Structure	Clearance
Interstate, Primary, and Urban Routes	30'-0" from edge of traffic lane
Ramp and Auxiliary Lanes	5'-3" from shoulder line
Other State Routes	5'-3" from shoulder line
Other streets and roads	5'-3" from shoulder line 2'-0" from face of barrier curb
(***) Railroads	14'-0" and 22'-0"

(***) Measured from centerline of track. The minimum clearance of 22'-0" to be provided on one side of the track(s) is for off-track maintenance. If it is not obvious on which side of the track(s) this clearance is to be provided, a decision should be obtained from the railroad's local representative. The assistance from Division of Multimodal Operations may be required in some situations.

Where a narrow median is used, provide 5'-6" minimum clearance from the edge of the traveled lanes to the face of the columns on the median side.

(**) See the Design Layout for minimum clearance.

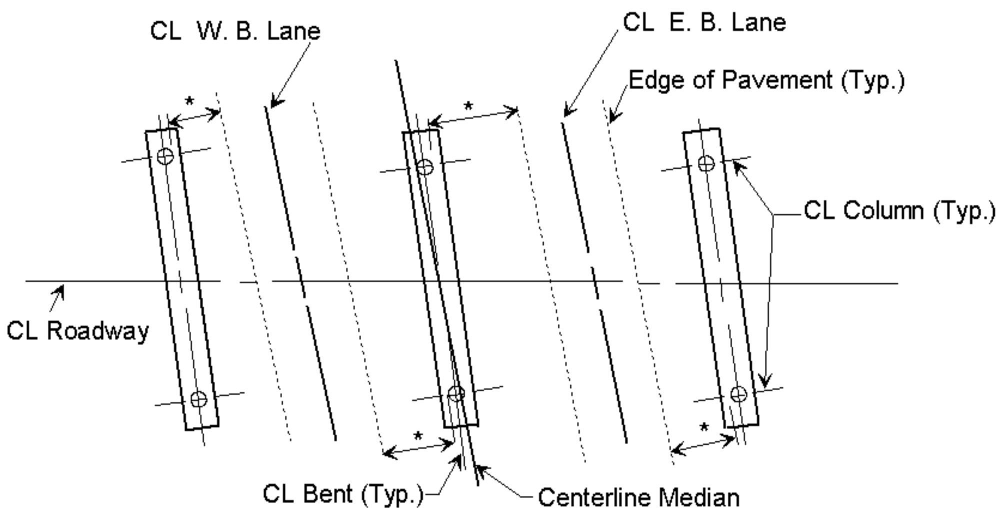


Figure 2.4.1.2 Horizontal Clearances

* Indicates horizontal clearance dimension to be shown on the front sheet of the bridge plans. (See the Design Layout for minimum clearance.)

Horizontal clearance for railroads shall be measured from the centerline of the tracks.

2.4.2 Boring Data

2.1 Front Sheet

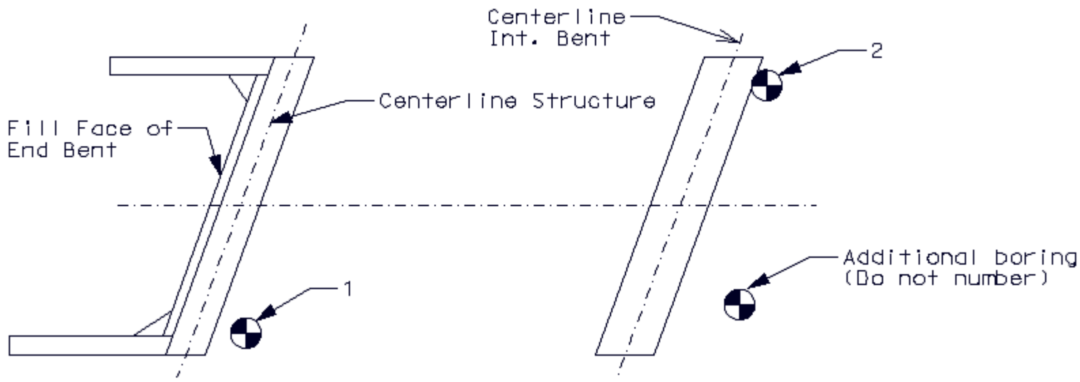


Figure 2.4.2.1 Plan View Boring Marker

All available boring data locations shall be shown with the boring symbol in the plan view on the front sheet. Detail only one boring per bent on the boring data sheet and number them accordingly. Numbered borings should try to be alternated side to side. Also give all cores.

Add boring data disclaimer note (see note E5.2 in *Office Notes* section) to the front sheet

2.2 Boring Data Sheet

* Indicates type of Boring only when core drill is used.

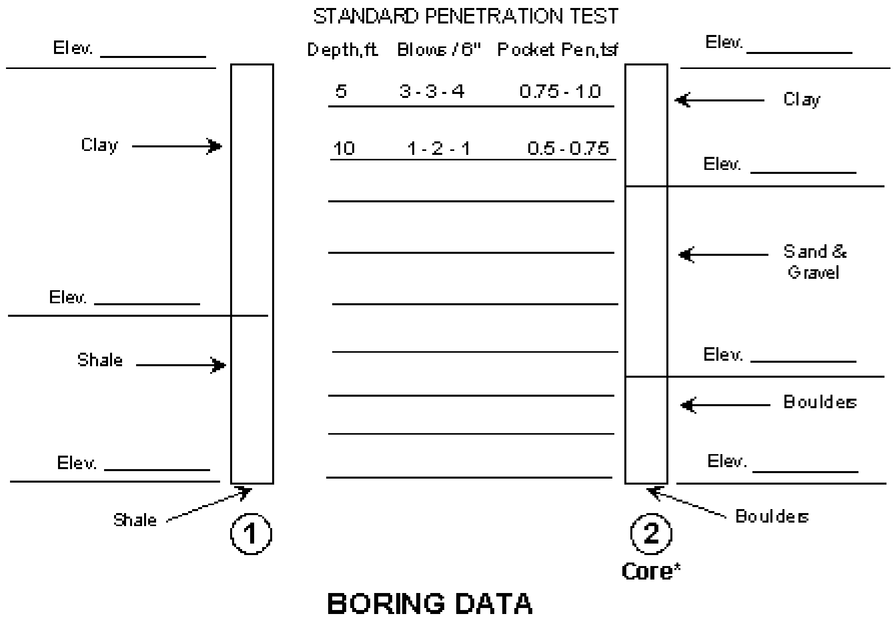


Figure 2.4.2.2 Boring Log

Add boring location note *(*see note E5.4 in *Office Notes* section *)* to the boring data sheet:

For location of borings, see Sheet No.__ .

2.4.3 *Hydraulics*

The following Tables for hydrologic and basic flood data are required on all bridge structures (stream crossings) and all standard box culverts. The hydrologic and basic flood data shall be given on the Design Layout.

See Structural Project Manager to determine which of the following Tables 2.4.3.1, 2 or .3 to be placed near the Location Sketch.

Table 2.4.3.1 Hydrologic and Flood Data for Culverts.

Hydrologic Data
Drainage Area =_____ (sq. mi.) Design High Water (DHW) Elev. =____ Design High Water Frequency =____(year) Design High Water Discharge =_____(cfs)
Backwater/Base Flood Data (100 year)
High Water Elev. =_____ Design Discharge =_____(cfs) Estimated Backwater =_____(ft) Outlet Velocity =_____(ft/s)
Roadway Overtopping
Design Elev. (1' below shoulder) =_____ Design Discharge =_____(cfs) Design Frequency =_____(year)

Table 2.4.3.2 Hydrologic and Flood Data for all Stream Crossings other than culverts.

Hydrologic Data
Drainage Area = ____(sq.mi.)
Backwater/Base Flood Data (100 year)
High Water Elev. =______ Design Discharge =______ Estimated Backwater =_____(ft) Average Velocity thru Opening =_____(ft/s)
Freeboard
Design Frequency =______(year) Design Discharge =______(cfs) Freeboard =_____(ft) Design High Water (DHW) Elev. =_____
Roadway Overtopping
Design Elev. (1' below shoulder) =_____ Design Discharge =______(cfs) Design Frequency =______(year)

Table 2.4.3.3 Hydrologic and Basic Flood Data for Culverts and Bridges

Hydrologic Data				
Drainage Area	=	(1)	sq. miles	(2)
Des. Discharge	=	(1)	cu. ft./second	((1) years *)
Des. H.W. Elevation	=	(1)	feet	((1) years *)
Estimated Backwater	=	(1)	feet	
Basic Flood Data (*)				
Discharge	=	(1)	cu. ft./second	((1) years)
H.W. Elevation	=	(1)	feet	
Estimated Backwater	=	(1)	feet	
Overtopping Flood Data				
Discharge	=	(3)	cu. ft./second	((3) years)

(1) If specified on the Design Layout. *

(2) Indicate the character of the drainage area as specified on the Design Layout or the Bridge Survey Report.

(3) Indicate the overtopping discharge and frequency if the frequency is less than 500 year. Indicate “Greater than 500 year” if the frequency is greater than 500 year.

(*) If the design discharge is for 100-year flood, omit Basic Flood Data Table and insert 100 years for ((1) years).

The frequency of the design discharge and the design high water elevation shall be indicated after their respective values.

The frequency is often shown on the Design Layout as a subscript to the particular item, or given in parenthesis behind the item.

Example:
Q10 - 10 year frequency for discharge.
H.W. Elev. (25 Yr. Freq.) - 25 year frequency for high water elevation.

2.4.4 Substructure Layout

Tangent Alignment

The following information should be used in conjunction with Figure 2.4.4.1

(1) Lengths parallel to the centerline of the roadway
(2) Column spacing along the centerline of the bent
(3) The side parallel to the centerline of the bents in skew diagram
(4) The side parallel to the centerline of the roadway in skew diagram
(5) The acute angle between the centerline of bents and the centerline of the roadway in skew diagram
(6) The angle between the centerline of the bents and a line normal to the centerline of the roadway in skew diagram

The span lengths for steel and prestressed structures given in the Design Layout are horizontal dimensions. For prestressed girders, the actual girder length should be adjusted accordingly for grade.

Horizontally Curved Alignment

The following sketches show the form and content to be used in detailing the substructure layout for some of the most common horizontal curve situations. When situations arise where modification of these sketches becomes necessary, the sketches should be used as a guide with regards to the form and content of the modified layout.

Attention should be given to the fact that in all cases illustrated here, the centerline of the roadway passes through the geometric center of the intermediate bents. On occasion, particularly in the case of continuous I-Beam spans, or where the slab is not symmetrical about the centerline of the roadway, this will not happen. In these and any other cases which may cause a similar situation, dimension "d", from the intersection of the centerline of the roadway with the longitudinal centerline of the bent, to the geometric center of the bent, must be shown (see Detail "A" in Figure 2.4.4.3). All bents will be parallel unless otherwise noted on the Design Layout.

The following key describes the dimensions marked on Figure 2.4.4.2, Figure 2.4.4.3, Figure 2.4.4.4 and Figure 2.4.4.5 in this Section.

1 Dimension along tangent
2 Offset from the tangent
3 Angle between chords of adjacent spans
4 Chord length
5 Dimension along the centerline of the median or roadway
6 Angle between the centerline of the bent and the chord
7 Angle between the fill face and the chord

8 Angle between the fill face and a radial line
9 Angle between the tangent and a chord
10 Skew angle
11 Dimension from the centerline of the median to the centerline of the lane in the direction of the centerline intermediate bent
12 Dimension from the centerline of the median to the centerline of the lane at the fill face

Short Bridges on Long Chords

Bridge Placed Parallel to the Long Chord

When noted on the Design Layout, short bridges on small horizontal curve alignments may be detailed on a line parallel to the long chord. The intent is to simplify the bridge geometric by placing the centerline of steel or P/S beam assembly on or parallel to the long chord to the centerline of roadway curve between fill faces of end bents. In order to avoid excessive slab overhangs, the line parallel to the long chord is usually placed at one-half the mid ordinate between curve and long chord. For this situation, the outside faces of the slab, barrier, rails, and wings shall be detailed concentrically with the roadway curvature, and curb ordinates shall be furnished on the plans.

It is to be noted that even for symmetrical width bridges, the location of bearings will not be symmetrical about the centerline of bents. Also, the intermediate bent caps shall be built to sufficient length on each end to accommodate the bearing offsets toward either end. See Figure 2.4.4.6.

Bridges Placed on the Long Chord

For wide roadways and very small degrees of curvature for which the mid ordinates are 3" or less, the Design Layout may occasionally direct that the entire bridge be detailed as a tangent bridge along the long chord. For this situation, no parts of the bridge are to be curved. Details for the plan view on the front sheet of the bridge plans will be similar to examples given on the following sheets except that the centerline of bridge roadway will be on the long chord.

Coordinating Superstructure - Curve Offsets

Plans for horizontally curved bridges shall contain the slab offset detail shown in Figure 2.4.4.7.

Slab offsets from chords, between the centerline of bents, shall be detailed at every 5'-0” along the chord. On circular curves, these offsets shall be spaced from the center of the chord to insure that the largest offset is recorded.

Substructure on Tangent Alignment

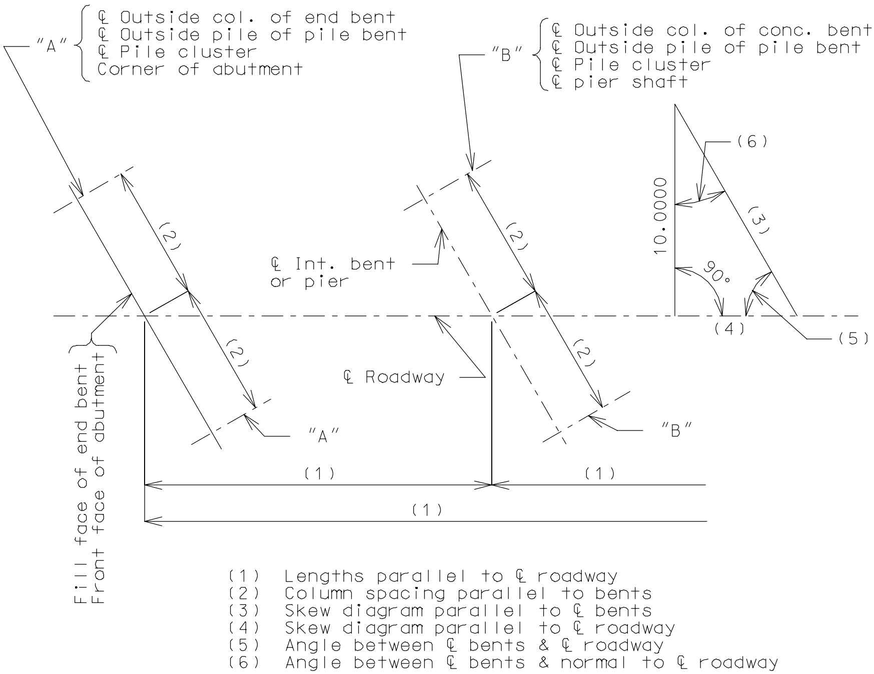


Figure 2.4.4.1 Coordinating Substructure on Tangent Alignment

NOTE:
The span lengths for steel and prestressed structures as given in the Design Layout are horizontal dimensions. The actual girder length should be adjusted accordingly for grade.

Horizontal Curved Alignment

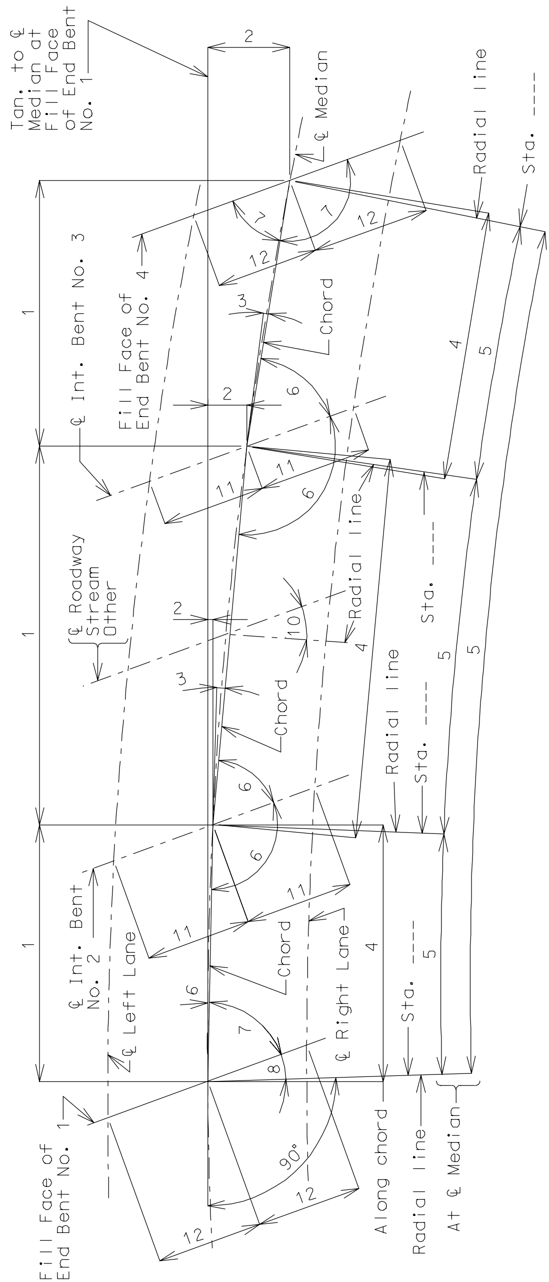


Figure 2.4.4.2 Dual Lane Structures Tied at Fill Face of End Bent

Horizontal Curved Alignment

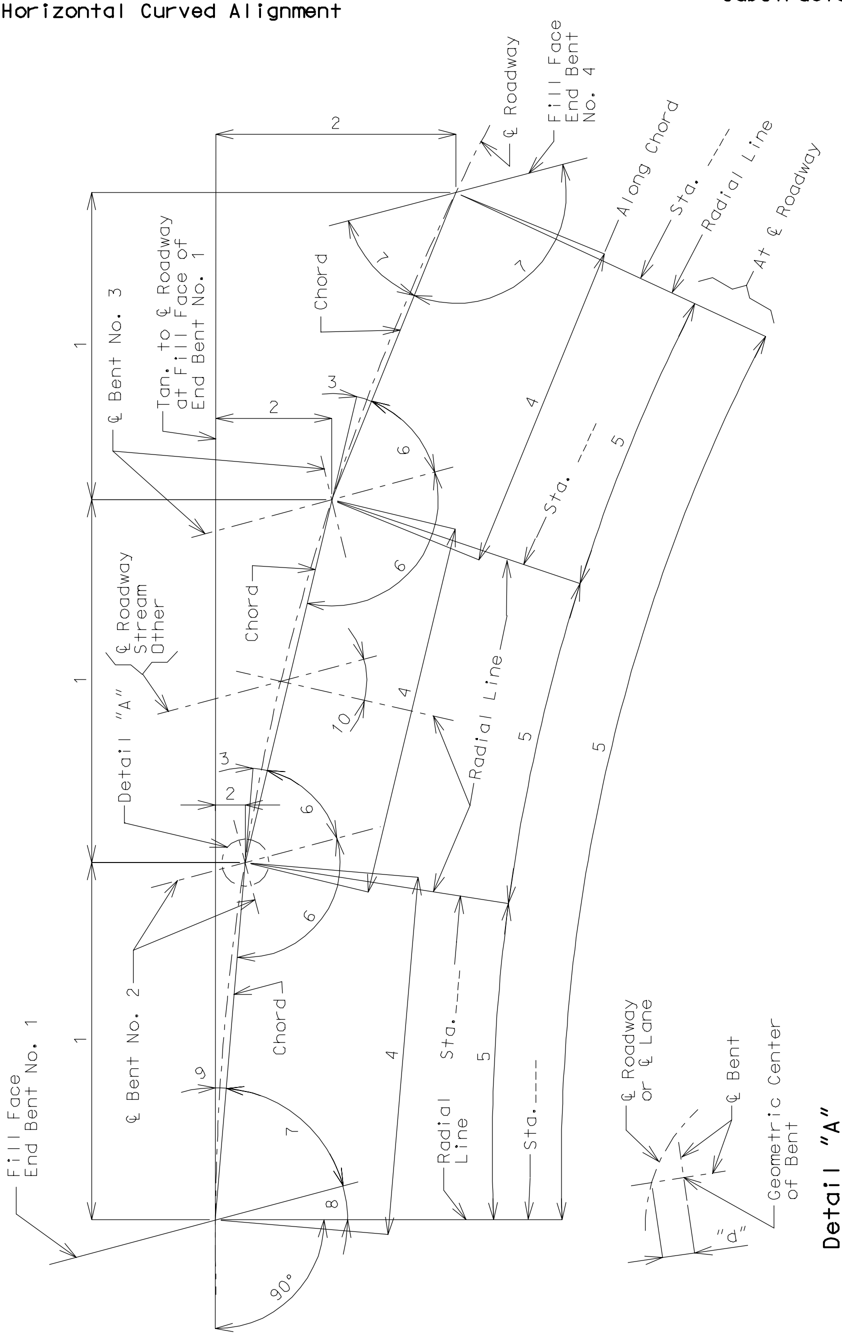


Figure 2.4.4.3 Single Lane Structure Tied at Fill Face of End Bent

Horizontal Curved Alignment

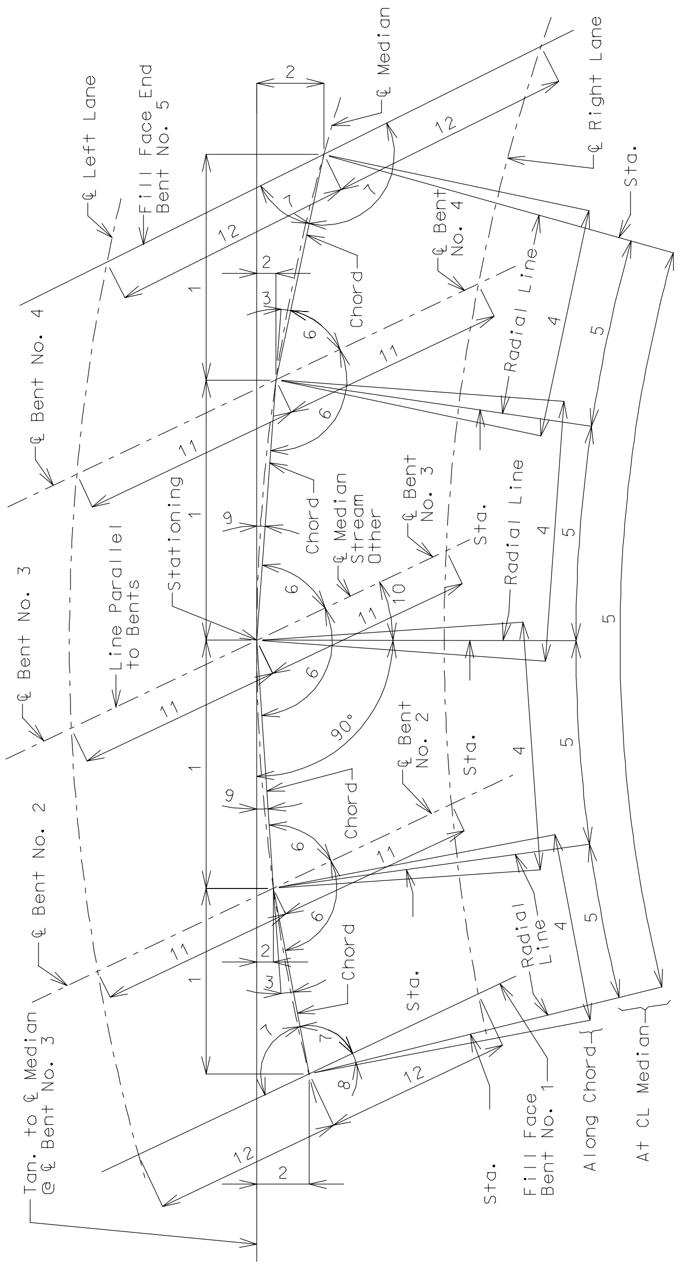


Figure 2.4.4.4 Dual Lane Structure Tied at Intersection

Horizontal Curved Alignment

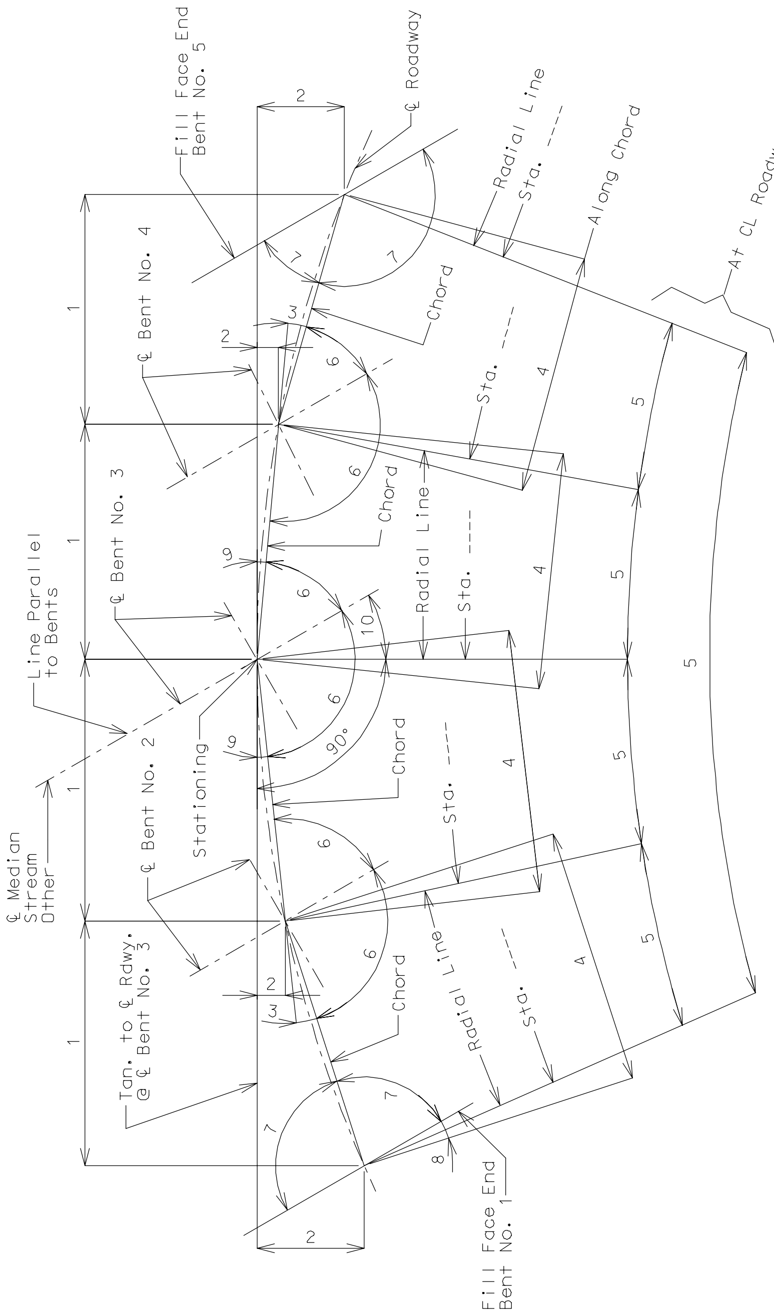
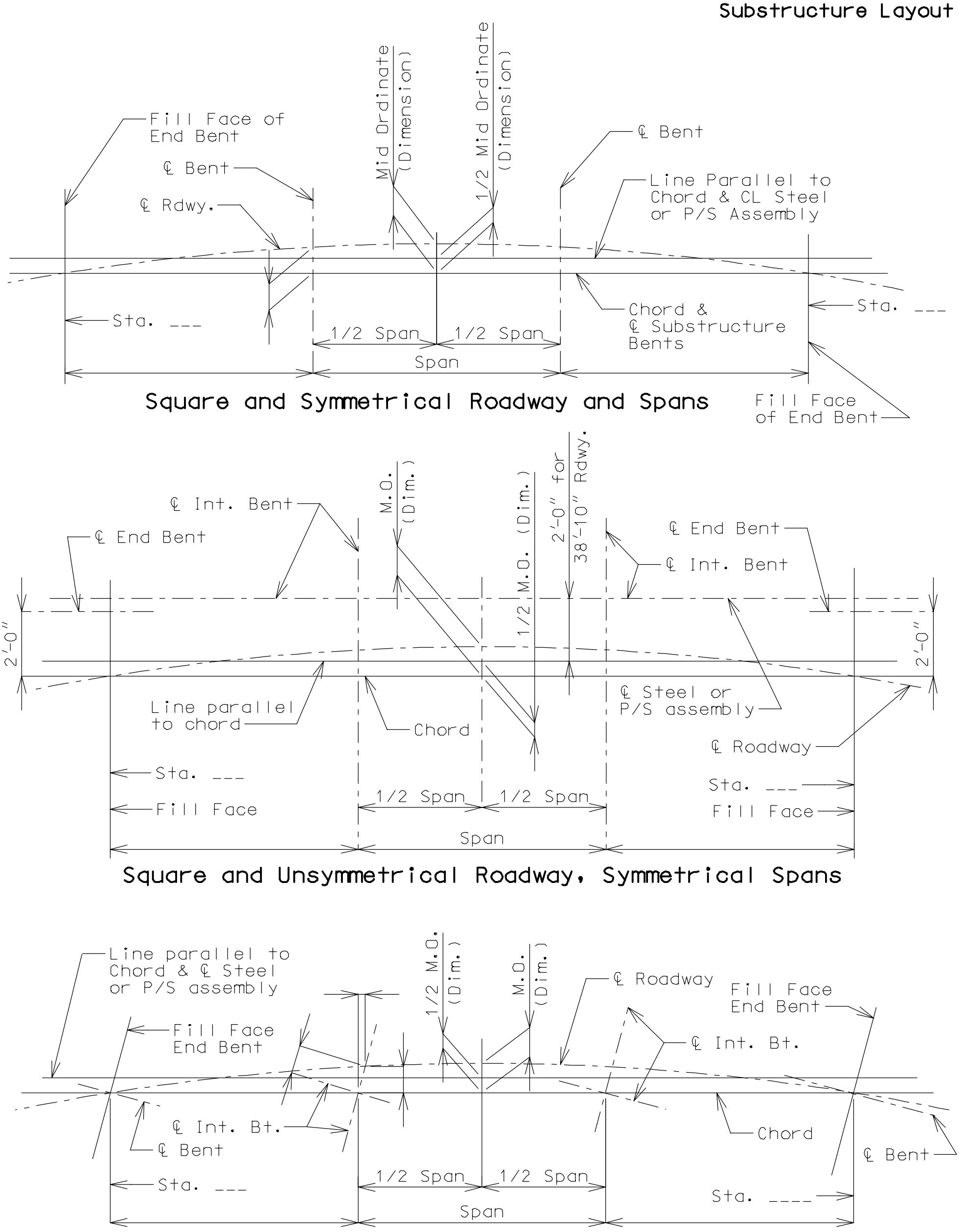


Figure 2.4.4.5 Single Lane Structure Tied at Intersection

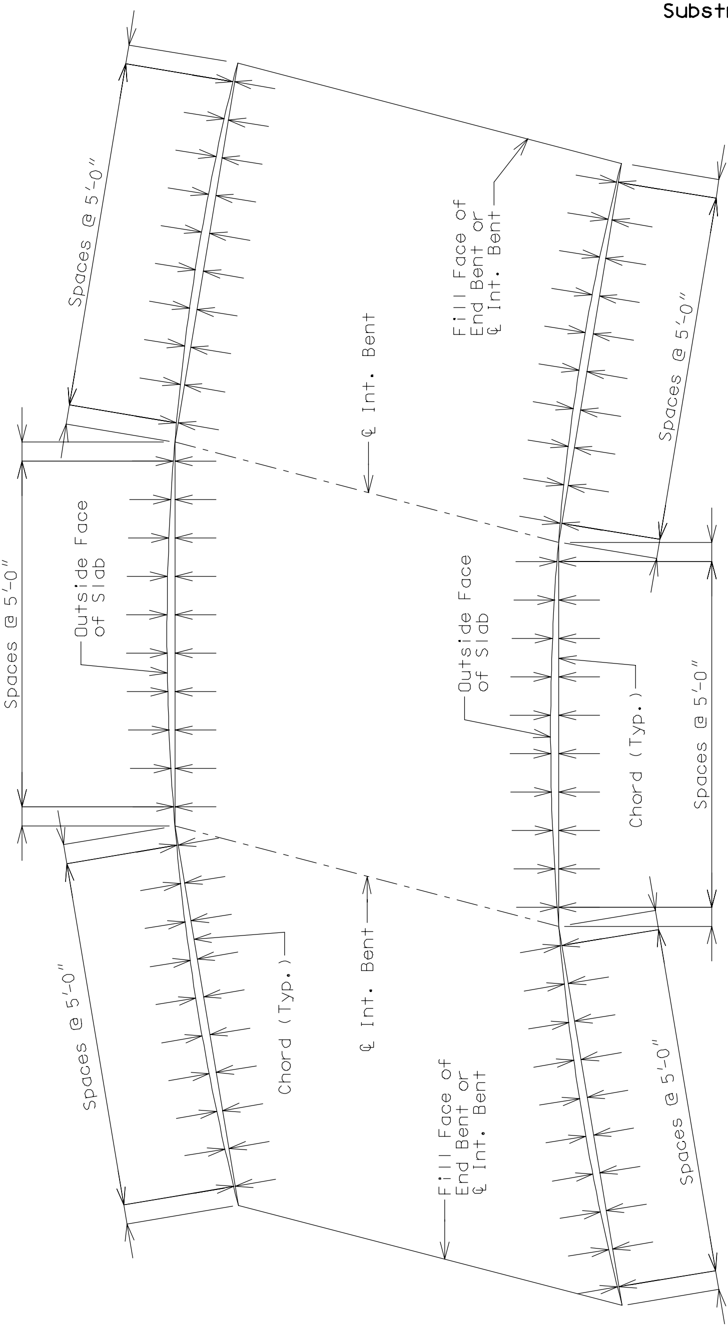


Square and Symmetrical Roadway and Spans

Square and Unsymmetrical Roadway, Symmetrical Spans

Skewed and Symmetrical Roadway and Spans

Figure 2.4.4.6 Short Bridges on Long Chords



Plan of Slab Showing Curve Ordinates

Figure 2.4.4.7 Slab Offsets for Curved Bridges

2.4.5 Front Sheet Misc. Details

Bench Mark

A bench mark in the vicinity of the bridge shall be provided on the front sheet and shall be located just above the title block as shown below in the following Figure 2.4.5.1.

B.M. Elev. 431.56 " □ " Chiseled on Abut. , N.W. Corner of
Bridge A1234 , Sta. 707+351.25
BRIDGE OVER HOMMES CREEK

Figure 2.4.5.1 Bench Mark

Location Sketch

A location sketch shall be provided on the front sheet of all bridge structures including box culverts and retaining walls. The location sketch may be eliminated on grade separation structures except where payment is made for removal of an existing structure or a congested area is involved such as a series of ramps, extended slope protection etc. When the location sketch is eliminated, place the north arrow near the plan view on the front sheet.

The location sketch for stream crossings should show the outline of the stream channel at the bridge site. The name of the stream should be given and the direction of flow indicated by an arrow on which is written the word "Flow". Any required channel change should be shown and labeled "Proposed Channel Change" and reference made to the road plans.

The centerline of the roadway should be shown and noted. The beginning station and outline of the new bridge should be shown and the new bridge labeled "Proposed Structure". The existing bridge, if any, should be shown and labeled "Existing Structure", and if it is a state bridge that is to be removed the bridge number shall be indicated in the location sketch. Place the north arrow near the Location Sketch.

Where structures are located on or within 150 feet of horizontal curves show complete curve data in the Location Sketch.

Standard Plan Sheets

Missouri Standard Plans (English Version) drawings applicable to a structure shall be made reference to on the front sheet of the bridge plans. The standard plan number(s) shall be located above the bridge number in the title block as shown in the following Figure 2.4.5.2.

Figure 2.4.5.2 Standard Plan Sheet Title Block

Information Block

The Figure 2.4.5.3 below shows the SEC. / SUR. (Section or Survey number), TWP. (Township) and RGE. (Range) that is included in the information block in the upper right corner of the front sheet.

STATE	PROJ. NO.		SHEET NO.
MO.			
SEC./SUR.	TWP.	RGE.	

Figure 2.4.5.3 Information Block

Construction Change Details

When the plans require changing after the bridge has been let the existing information must be kept on the plans. The changes shall be shown with details similar to the following Figure 2.4.5.4.

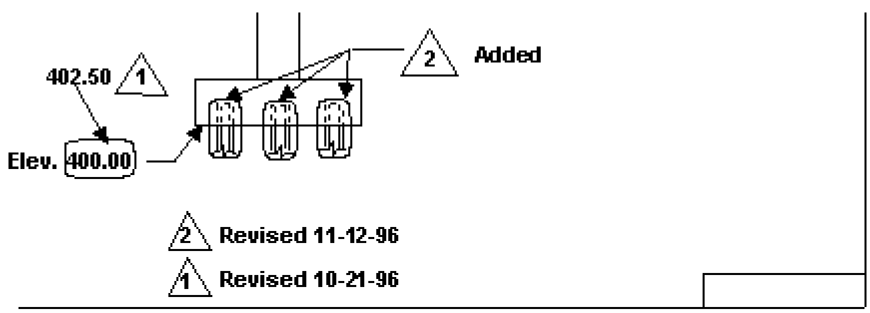


Figure 2.4.5.4 Construction Change Details

Curve Data

All curve data of roadways that are going over or under the bridge shall be provided on the front sheet.

Filled Joint Detail

When joint filler is indicated on the plans, include Section number of Missouri Standard Specifications indicated below.

- Superstructure . . . .
- Pedestrian Structures . .
- Retaining Walls . . . .

Sec. 1057
Preformed Sponge Rubber Expansion and Partition Joint Filler

- Culverts . . . .
- Slope Protection . . . .
- P/S Panels . . . .

Sec. 1057
Preformed Fiber Expansion Joint Material

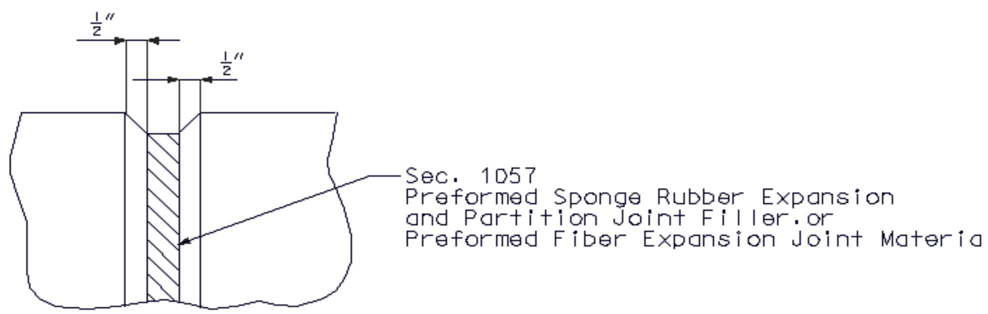


Figure 2.4.5.5 Filled Joint Detail

Rock Blanket - Revetment Front Sheet Misc. Details

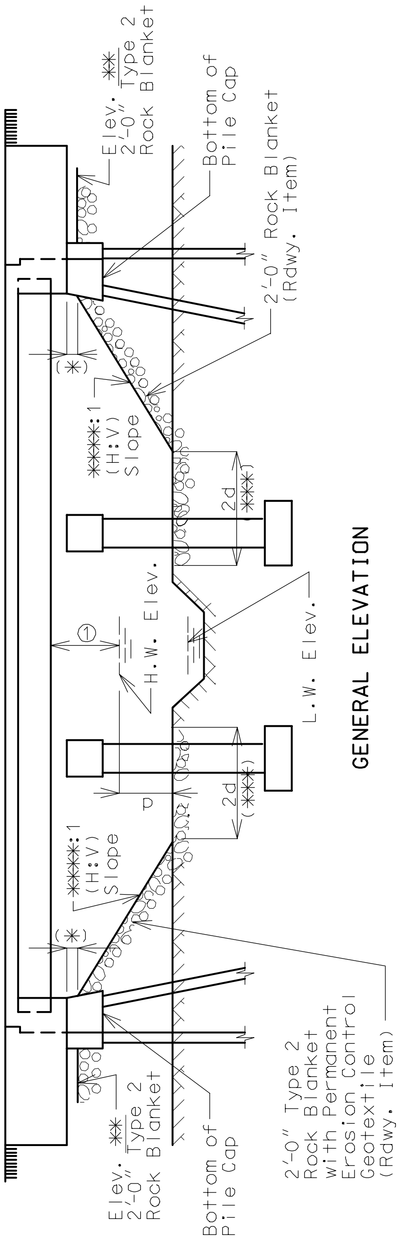
When a rock blanket is specified on the Profile Sheet of layout file it should be shown in the General Elevation of the front sheet. Surface Grout or Type 3 Geotextile Material shall also be noted if they are needed. The following Figure 2.4.5.6 shows common rock blanket details.

* 12" between top of spill slope and lowest beam depth for Girder Bridges and 24" for Concrete Slab Bridges.

** Elev. at top of Rock Blanket for side slopes shall be the highest of the following:
12" above High Water Elevation (For 500 Yr. Freq.) or
24" above High Water Elevation (For 100 yr. Freq.)

Upper Elev. of Rock Blanket on spill slope need not be higher than that for the side slope.

① = 2'-0"(Min.) for Drainage Area 20 sq. miles and over;
① = 1'-0"(Min.) for Drainage Area less than 20 sq. miles.



GENERAL ELEVATION

Figure 2.4.5.6 Rock Blanket Detail

Note: When Surface Grout or Type 3 Geotextile Material is specified on profile sheet it should be noted in the GENERAL ELEVATION. Outlets may be used over Permanent Erosion Control Geotextile Material. See Bridge Plans for type of curb to be used.

*** A Rock Blanket Apron should extend from the toe of the Spill Slope into the bridge waterway a distance equal to twice the Flow Depth in the overbank area near the embankment, but need not exceed 25 feet.

**** See Design Layout for maximum slope of spill fill (Maximum allowable spill fill slope is determined by Construction and Materials Division and Materials Division as specified in the Soils Survey for each project).

2.4.6 General Detailing

Bridge MicroStation Manual

Levels

All Cadd drawings shall be drawn in MicroStation and shall have the following levels, colors and line weights.

1	Concrete object lines (color 1 gray, weight 5)
2	Reinforcing steel (color 4 green, weight 4)
3	Structural steel object lines (color 4 green, weight 4)
4	Hidden lines (dashed 2, color 4 green, weight 4)
5	Centerlines (centerline 4, color 5 yellow, weight 2)
6	Dimensions (color 5 yellow, weight 2)
7	Leadered notes (color 5 yellow, weight 2)
8	Small text (color 5 yellow, weight 2)
9	Medium text (color 1 gray, weight 5)
10	Large text (color 2 red, weight 7)
11	Existing structure (lt. dash 1, color 5 yellow, weight 2)
12	Cells (variable colors and weights)
13	Area fill (color 7 magenta, weight 1)
14	Section lines (color 2 red, weight 7)
15	Quantity boxes and tables (variable colors and weights)
16	Ground line (color 1 gray, weight 5)
17	Annotations (No color or weight required)
18	Break and match lines (color 5 yellow, weight 2)
19	Misc. object lines (color 5 yellow, weight 2)
20	Points (color 7 magenta, weight 8)

Conventions

Reinforcing steel, except when sectioned, is shown by a single line. Centerlines are represented by a single dot between dashes. Hidden surfaces are represented by short dashed lines as shown below.

Water surfaces will be shown by broken or dashed lines as shown below.

The hatching of ground lines shall be shown as follows.

Miscellaneous

Lines used to indicate the magnitude of angle between two straight lines shall be an arc drawn with the center at point of intersection of the two lines. Arrows and dimension lines shall touch the items or extension lines they point to. Dimension lines shall be normal to extension lines whenever possible.

Dimensions and Leadered Notes

Dimensions and leadered notes shall be placed as close to the detail as possible and shall cross a minimum number of lines and details.

A bracket is normally not required for a multi-line note. The leader line should originate from the beginning or end of the note.

When designating a structural steel member, the leg the arrow points to should be the first value mentioned in the note.

When designating a number of parallel lines (such as reinforcing bars), a dimension line shall be used between the outside lines of the group. If the desired text will not fit clearly on the dimension line, the text may be placed away from the dimension line, and attached to the dimension line's center by an arrow. Arrowheads placed inside the extension lines should have a minimum clearance of 3/8" between the arrows.

Sections, Breaks and Curved Surfaces

Locating Sections

In general, the location of all sections shall be shown by use of heavy lines placed just outside the limits of the detail or portion of detail sectioned. Where, for the sake of clarity, it is necessary to show the direction of the view taken, arrows may be used at the ends of these lines and at right angles thereto. A reference letter shall be placed at these lines or arrows and the same letters used in the titles under sectional views. Views are normally shown looking in the direction of stationing, with the exception of End Bent No.1, which is reversed.

Hatching

Sectional views cutting through concrete shall be hatched with the conventional dot and triangle or oval hatching. Care shall be taken to avoid dense or crowded hatching, particularly for sections showing reinforcing steel.

Sectional views through reinforcing steel shall be shown solid. Sectional views through structural steel shall be shown as parallel sloping line hatching. In special cases, for the sake of clarity, the sections through structural steel may be left open or shown solid.

Except for special cases, all miscellaneous materials such as joint filler, castings, lead plate, etc. shall have sectional views shown hatched with light parallel lines, evenly spaced and sloped 45 degrees to the horizontal.

Breaks may be used in views for sake of clarity. All breaks should be drawn without excessive waving or zig-zag movements. A loop may be used in showing breaks in round objects such as columns.

Sloped or curved surfaces shall not be shaded except for special cases.

Lettering

All lettering shall be upper and lower case except titles, which shall be all capital letters in bold print.

Bridge MicroStation Manual

Text Height

Body text shall be 0.0104 foot (1/8 inch) in height, titles shall be 0.0156 foot (3/16 inch) in height and the county name shall be 0.0208 foot (1/4 inch) in height.

Dimensions

Dimensions

All details should be in English units only. No dual dimensioning will be used. Print unit name in lower case, even those derived from a proper name except for Fahrenheit (F.).

Use only feet and inches for length measurements. Dimensions under 2'-0" shall be detailed as inches.

In general, detail dimensions shall be given to the nearest 1/8". Where close work is required, dimensions for metals may be given to the nearest 1/16", 1/32" or 1/64". Deflections and haunches shall be reported to the nearest 1/16". Substructure layout for horizontally curved bridges shall be dimensioned to the nearest 1/16".

Nominal span lengths at the top of the front sheet shall be reported in feet and inches only.

The term or abbreviation for "about" shall not be used in the dimensioning of structural steel.

Stationing
Stations are one hundred feet. All stationing should be carried to the nearest hundredth foot as follows: 251+50.14.

Elevations
All elevations will be reported in feet. All elevations will be carried to the nearest hundredth foot as follows: 1234.98.

PLAN and GENERAL ELEVATION for a *skewed* bridge shall be shown on Sheet 1 of a set of plans:

The “Plan” should be drawn to scale. The “General Elevation” should be drawn as a section through centerline of structure but showing the side elevation of the end bent wing walls and safety barrier curbs. Only one pier column will be shown (No isometric views of the structure). The centerline of bents should “line up” on the Plan and Elevation.

2.4.7 Numbers and Symbols

Rules for Writing Numbers & Slopes

Use feet and inches for length measurements. Make inch and foot marks of medium lengths (about 1/16") and place them to the upper right of numbers to which they refer.

Use fractions, not decimals for inches (3/4", not 0.75"; 2-1/2", not 2.5").

Common fractions shall be written with a vinculum separating the numerator from the denominator. These bars shall be placed horizontally except for rare cases where lack of space makes this impractical or when placed within a note. Common fractions shall always be given on the basis of architects' scale.

Some examples of fractions used in a note are:
two 3/4" dia. coil tie rods
2-1/2" x 1-1/4" plate
2'-0 3/8" long bar

The decimal marker shall be a period.

Slope is expressed in non-dimensional ratios. The horizontal component will be shown first followed by the vertical component (H:V). The horizontal component is unitary for slopes greater than 45° and the vertical component is unitary for slopes less than 45°. The components in a slope ratio must be of identical units.

Rules for Writing Symbols

Only approved symbols shall be used for noting reinforcing bars, structural steel shapes, bolts, welding, dimensions, angles, etc. Symbols shall not be omitted where they apply except in authorized designation of structural steel shapes. Welding symbols shall be in accordance with American Welding Society (AWS).

2.4.8 Abbreviations

In general, abbreviations shall not be used in notes or drawings except for short notes located where space is very limited. Care shall be taken to avoid the extravagant use of abbreviations for any purpose. However, approved abbreviations may be conservatively used for noting and labeling the various items and details of the plans and of the tabulated data. Titles may be abbreviated where required by lack of space.

The following is a partial list of approved abbreviations and should be observed where applicable.

American Association of State Highway and Transportation
Officials -- AASHTO
About -- Abt.
Abutment -- Abut.
And -- &
Angle -- Ang.
Approach -- Appr.
Approximately -- Approx.
Approved -- Appv.
Alternate, Alternately -- Alt.
Area -- Ar.
Asphalt -- Asph.
American Society for Testing and Materials ----- ASTM
Avenue -- Ave.
Average -- Avg.

Baluster -- Bal.
Backfill -- Bkfl.
Beam -- Bm.
Bench Mark-- B.M.
Bearing -- Brg.
Bent -- Bt.
Bevel -- Bev.
Bituminous -- Bit.
Bottom -- Bott.
Bracket -- Brkt.
Bridge -- Br.
Building -- Bldg.

Cantilever -- Cant.
Cast Iron -- C.I.
Centers -- Cts. or Ctrs.
Center to Center -- Ctr. to Ctr.
Channel (Stream) -- Chan.
Clear or Clearing -- Cl.

Collision (Wall)	Coll.
Column	Col.
Concrete	Conc.
Concrete Reinforcing Steel Institute	CRSI
Connection	Conn.
Construction	Const.
Continuous	Cont.
Corrugated	Corr.
Counterfort	Ctft.
Countersunk	Ctsk.
County	Co.
Creek	Cr.
Creosoted	Creo.
Cubic (Yd., Ft., In.)	Cu.
Cubic feet per second	cfs.
Culvert	Culv.
Dead Load	D.L.
Deck Girder	D.G.
Department	Dept.
Design	Des.
Detail	Det.
Diagram	Diag.
Diameter	Dia.
Ditto (Steel Details)	Do.
Division	Div.
Double	Dbl.
Drawing	Dwg.
East	E.
Elevation	Elev. or El.
Engineer	Engr.
Estimate	Est.
Excavation	Exc.
Existing	Exist.
Expansion	Exp.
Fabricated	Fab.
Far Side (Steel Details)	F.S.
Federal	Fed.
Feet or Foot	Ft.
Fixed	Fix.
Flange	Flg.
Floor	Fl.
Galvanize	Galv.
Gauge	Ga.
Grade	Gr.

Head	Hd.
Hexagonal	Hex.
High Water	H.W.
Highway	Hwy.
Horizontal	Hor.
Impact	I.
Inch or Inches	In.
Include	Incl.
Joint	Jt.
Lateral (Steel Details)	Lat.
Left	Lt.
Length	Lgth.
Linear, Lineal (Ft., In.)	Lin.
Live Load	L.L.
Longitudinal	Long.
Low Water	L.W.
Maximum	Max.
Miles	Mi.
Minimum	Min.
Miscellaneous	Misc.
Missouri Department of Transportation	MoDOT
Near Side (Steel Details)	N.S.
North	N.
Number	No.
Octagonal	Oct.
Ordinate	Ord.
Overflow	O.F.
Overhead	O.H.
Paragraph	Par.
Perpendicular	Perp.
Plate	Pl.
Point	Pt.
Pound	Lb
Project	Proj.
Radius	Rad. (or R.)
Railroad	R.R.
Railway	Rlwy.
Reinforcing	Reinf.
Retaining (Wall)	Ret.
Right	Rt.
River	R.
Roadway	Rdwy.

Route	Rte.
Rubber Compound	Rub. Comp.
Section	Sec.
Sheet	Sht.
Shoulder	Sh.
South	S.
Space	Spa.
Specification	Spec.
Square	Sq.
Standard	Std.
Station	Sta.
Street	St.
Stringer	Str.
Structural	Struc.
Substructure	Substr.
Superelevation	Superelev. or S.E.
Superstructure	Superstr.
Symmetrical	Symm.
Tangent	Tan.
Thread	Thd.
Transverse	Trans.
Truss	Tr.
Typical	Typ.
Variable	Var.
Vertical	Vert.
West	W.
Widen or Widening	Wid.
Wrought Iron	W.I.
Yard	Yd.

The following shall be used for units for pay items in Quantity Tables (No abbreviations shall be used unless indicated):
each
cu. yard
gallon
linear foot
lump sum
pound
sq. foot
sq. yard
ton

2.4.9 Welding Details

All welding shall be detailed in accordance with ANSI / AASHTO / AWS D1.5, Bridge Welding Code.

The following chart is the suggested minimum weld sizes based on past history; however, these may be increased to satisfy design requirements.

Minimum Fillet Weld	Material thickness of thicker part joined
1/4"	$t \leq 3/4"$
5/16"	$3/4" < t \leq 2\text{-}1/2"$
1/2"	$t > 2\text{-}1/2"$

The factored resistance of a welded connection is governed by the resistance of the base metal or the deposited weld metal.

LRFD 6.13.5.3

The factored resistance of the base metal is:

$R_r = \phi_v \ (0.58 A_g F_y)$

Where:

LRFD 6.5.4.2

ϕ_v = 1.0 (Resistance factor for shear)

A_g = gross area of smaller connection element

F_y = specified minimum yield strength of connection element

Allowable shear load of the base metal = $R_r \ A_g$

The factored resistance of the deposited weld metal is:

$R_r = 0.6 \ \phi_{e2} F_{exx}$

LRFD 6.5.4.2

Where:

ϕ_{e2} = 0.8 (Resistance factor for fillet weld material)

F_{exx} = tensile strength of electrode classification.

Allowable Shear Loads for Fillet Welds = $(R_r)(0.707)$(weld size)

Size of Fillet Weld (Inch)	**Allowable Factored Shear Loads For Fillet Welds *** (kips per linear inch)
1/4	5.939
5/16	7.424
3/8	8.908
1/2	11.878
5/8	14.847
3/4	17.816
7/8	20.786
1	23.755

* based on F_{exx} = 70 ksi

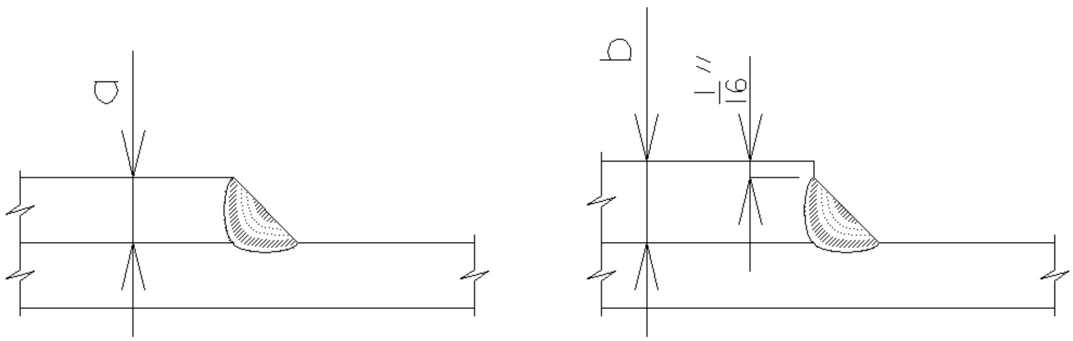
Minimum Length of Fillet Weld

LRFD 6.13.3.5

The minimum effective length of a fillet weld shall be four times its size and in no case less than 1-1/2”.

Maximum Sizes of Fillet Welds

LRFD 6.13.3.4



$a < 1/4"$ $b \geq 1/4"$

Figure 2.4.9.1 Maximum Fillet Weld Sizes

Basic Welding Symbols and Their Location Significance

Location Significance	Fillet	Plug or Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Flange Corner	Flange Edge
Arrow Side									
Other Side				Not Used			Not Used		
Both Sides		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
No Arrow Side or Other Side Significance	Not Used	Not Used		Not Used		Not Used	Not Used	Not Used	Not Used

Figure 2.4.9.2 Standard Welding Symbols from AWS A2.4

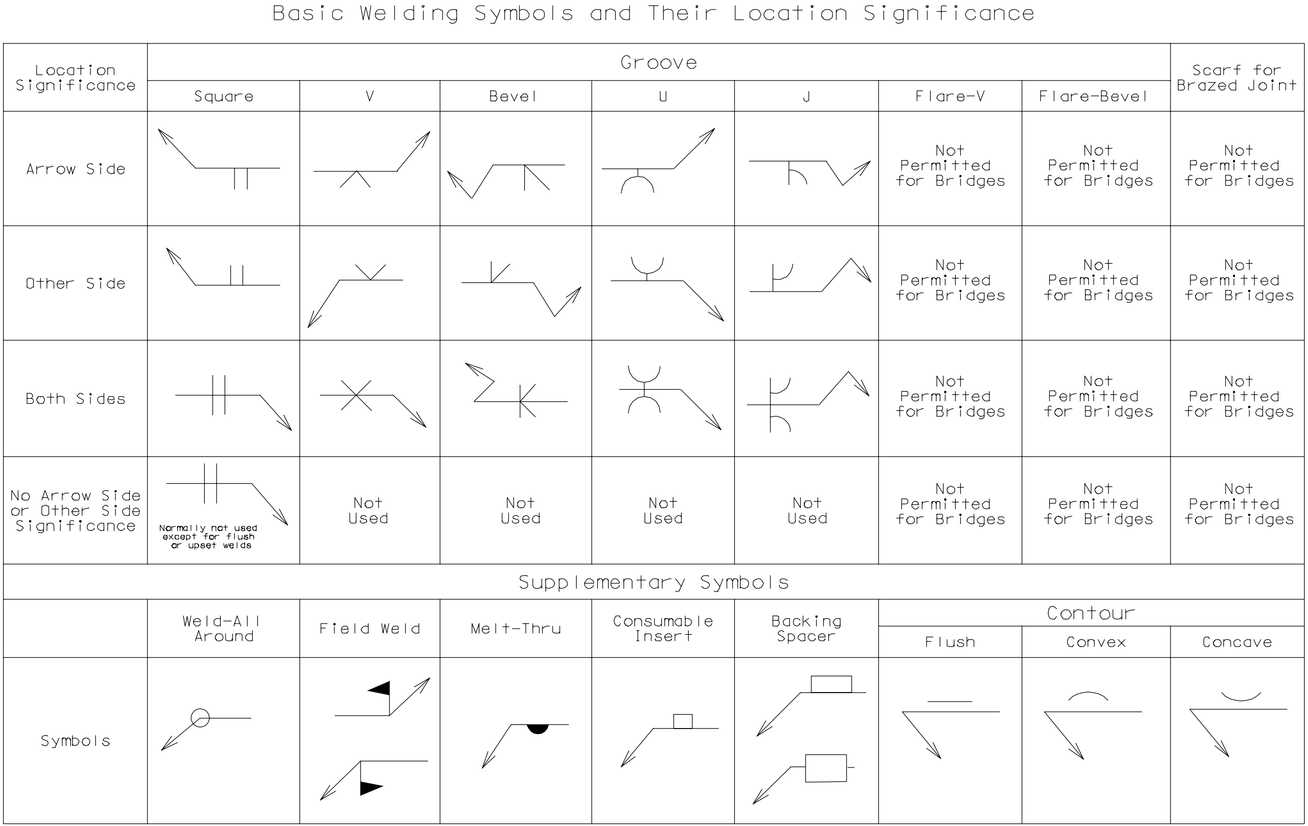


Figure 2.4.9.3 Standard Welding Symbols from AWS A2.4

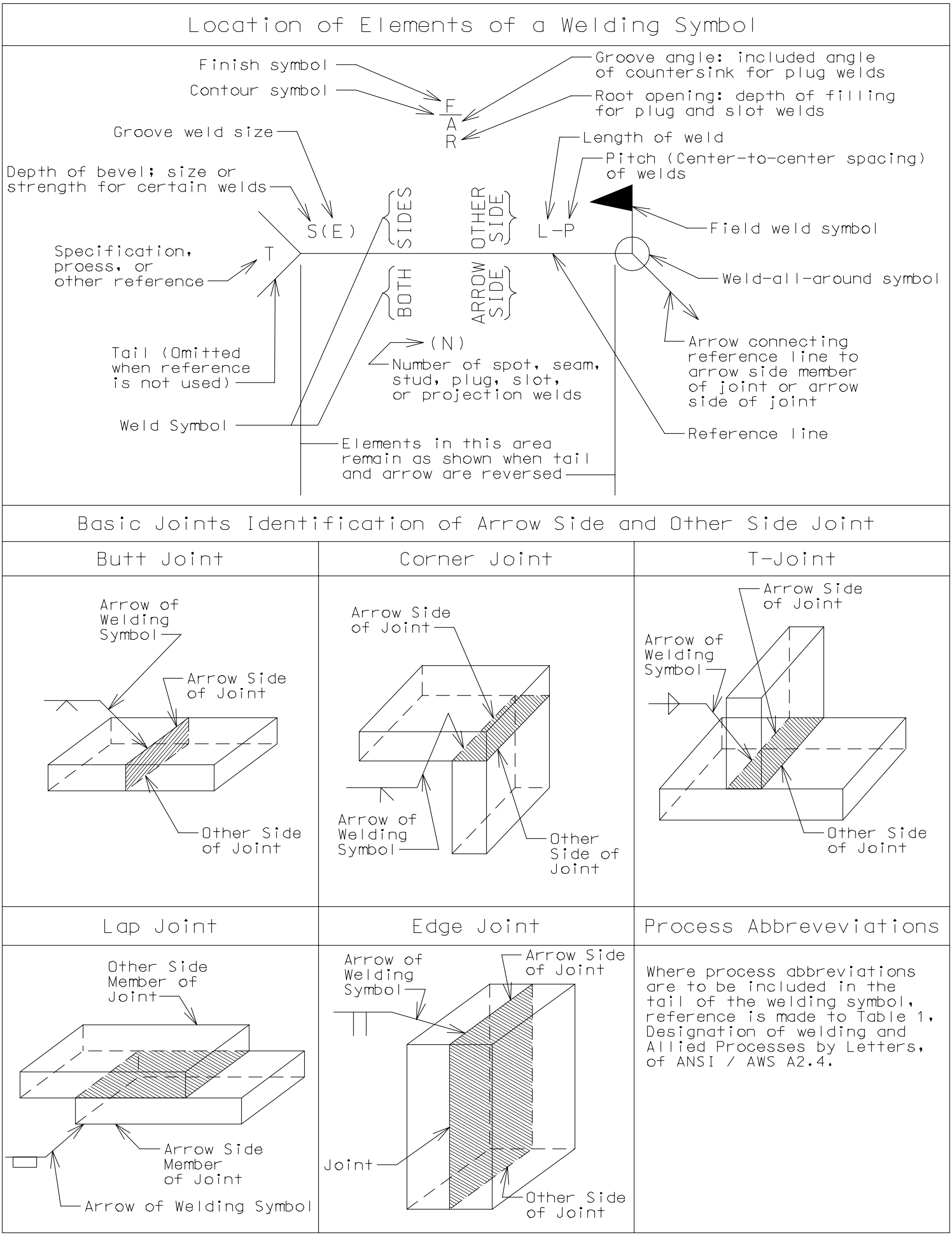


Figure 2.4.9.4 Standard Welding Symbols from AWS A2.4

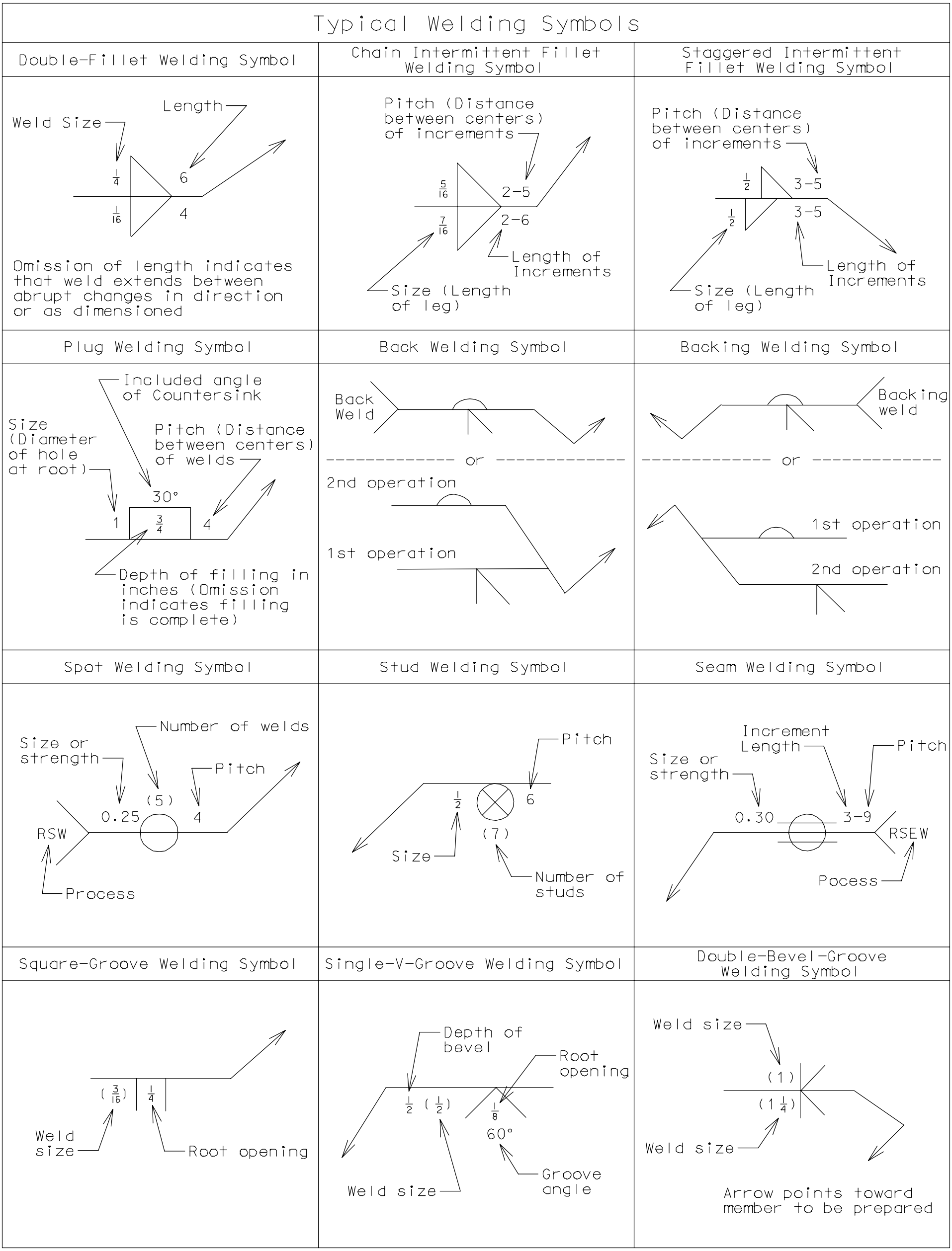


Figure 2.4.9.5 Standard Welding Symbols from AWS A2.4

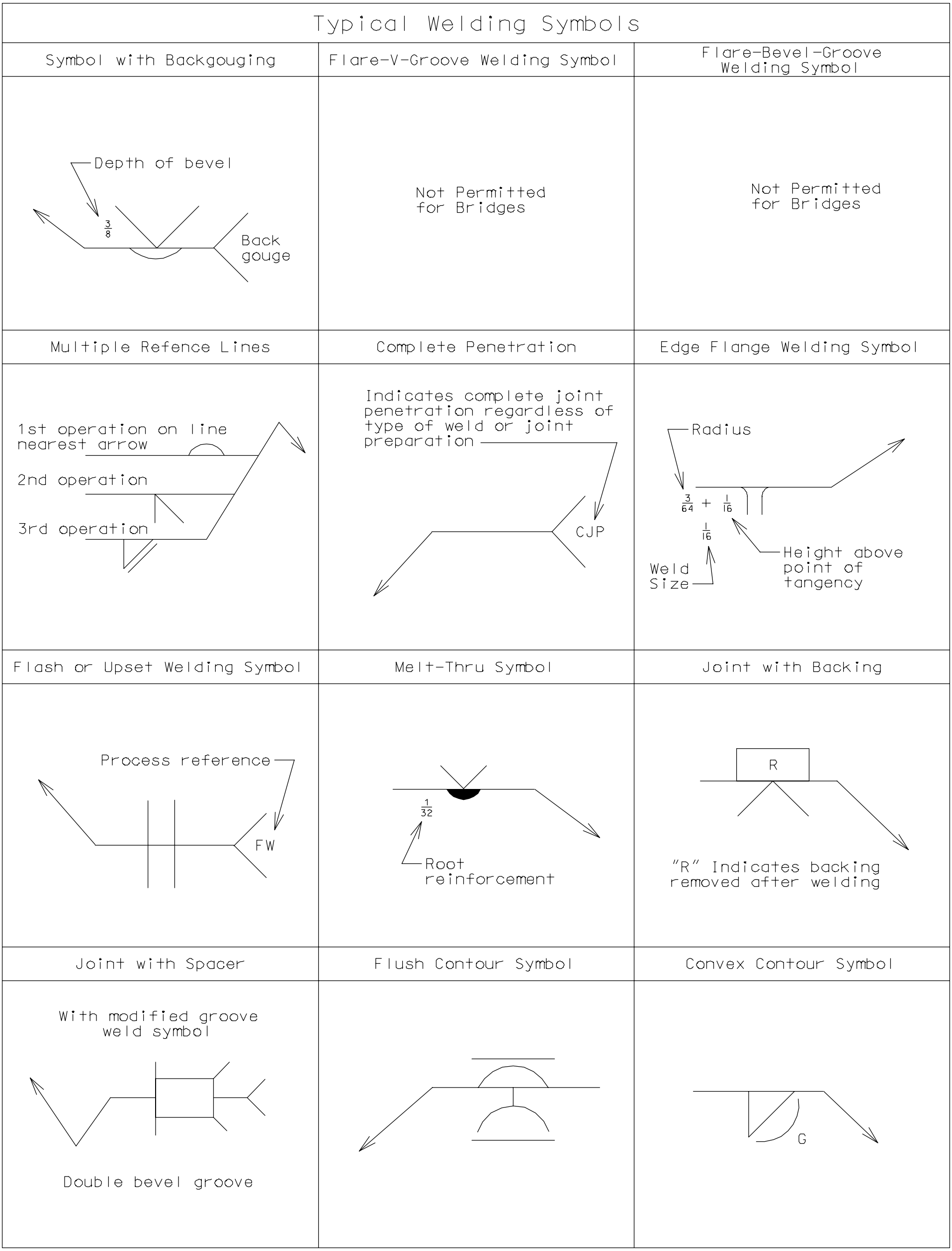


Figure 2.4.9.6 Standard Welding Symbols from AWS A2.4

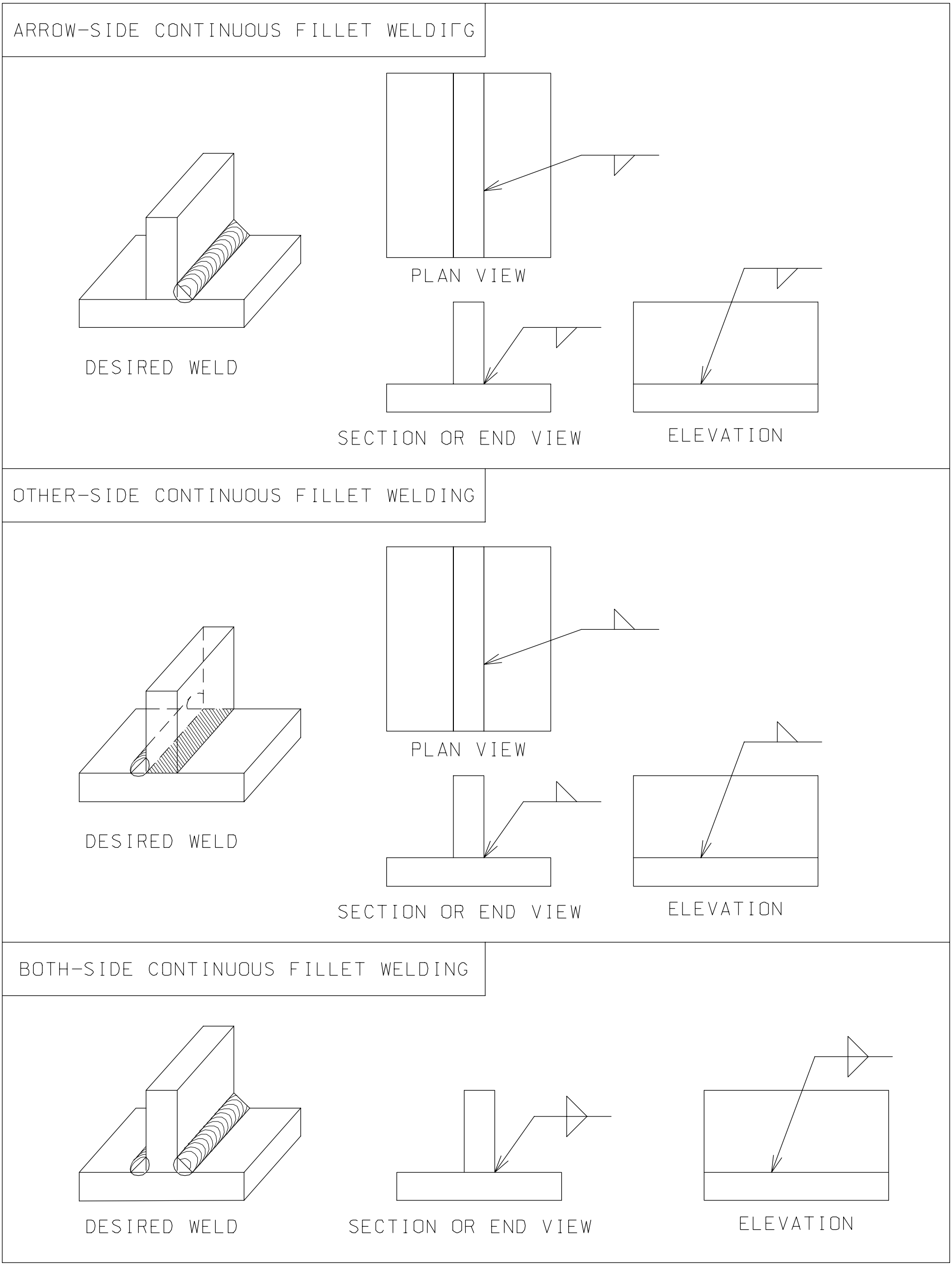


Figure 2.4.9-7 Application of Symbols - Fillet Welds - General

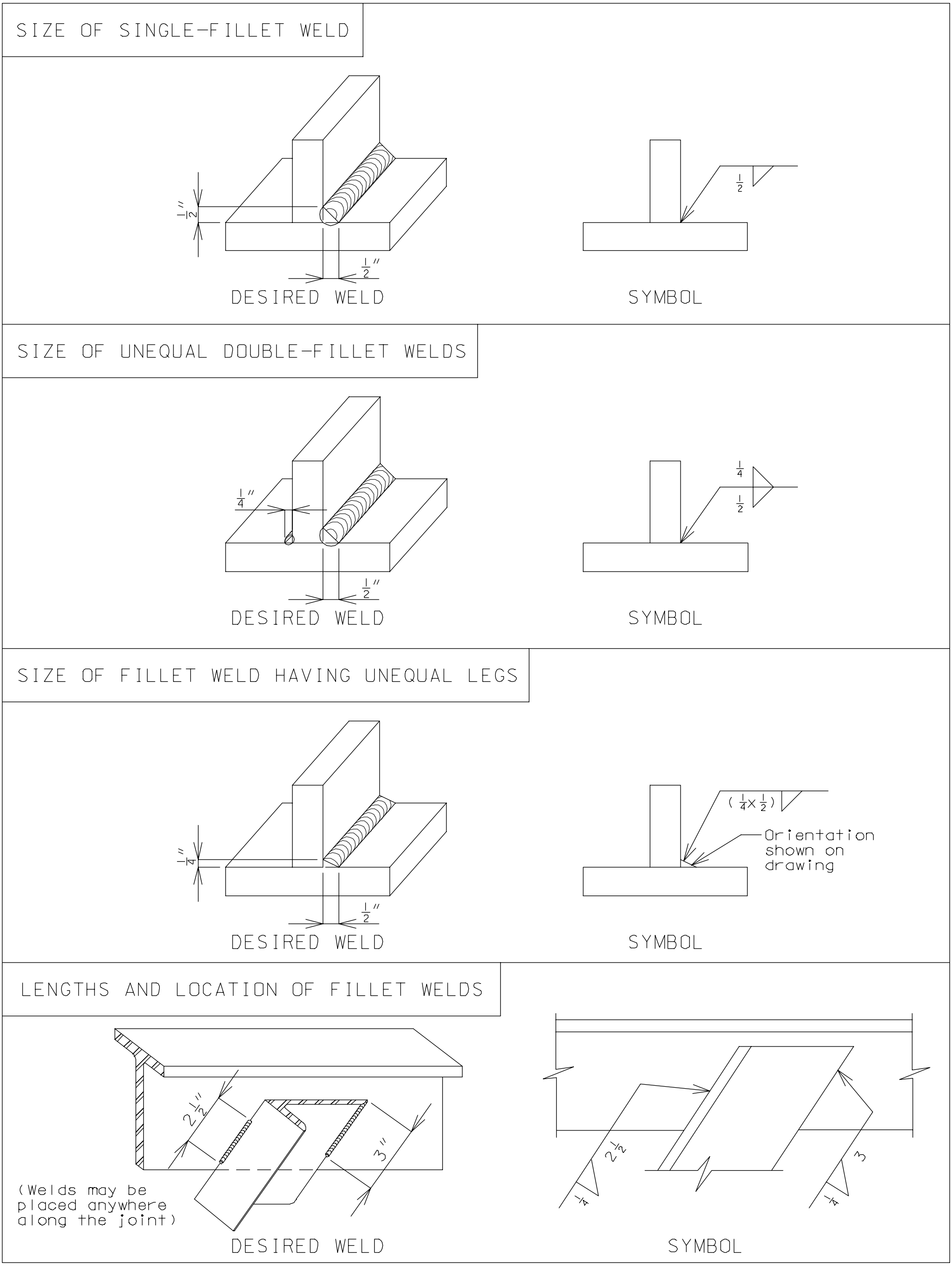


Figure 2.4.9-8 Application of Symbols - Fillet Welds - Dimensions

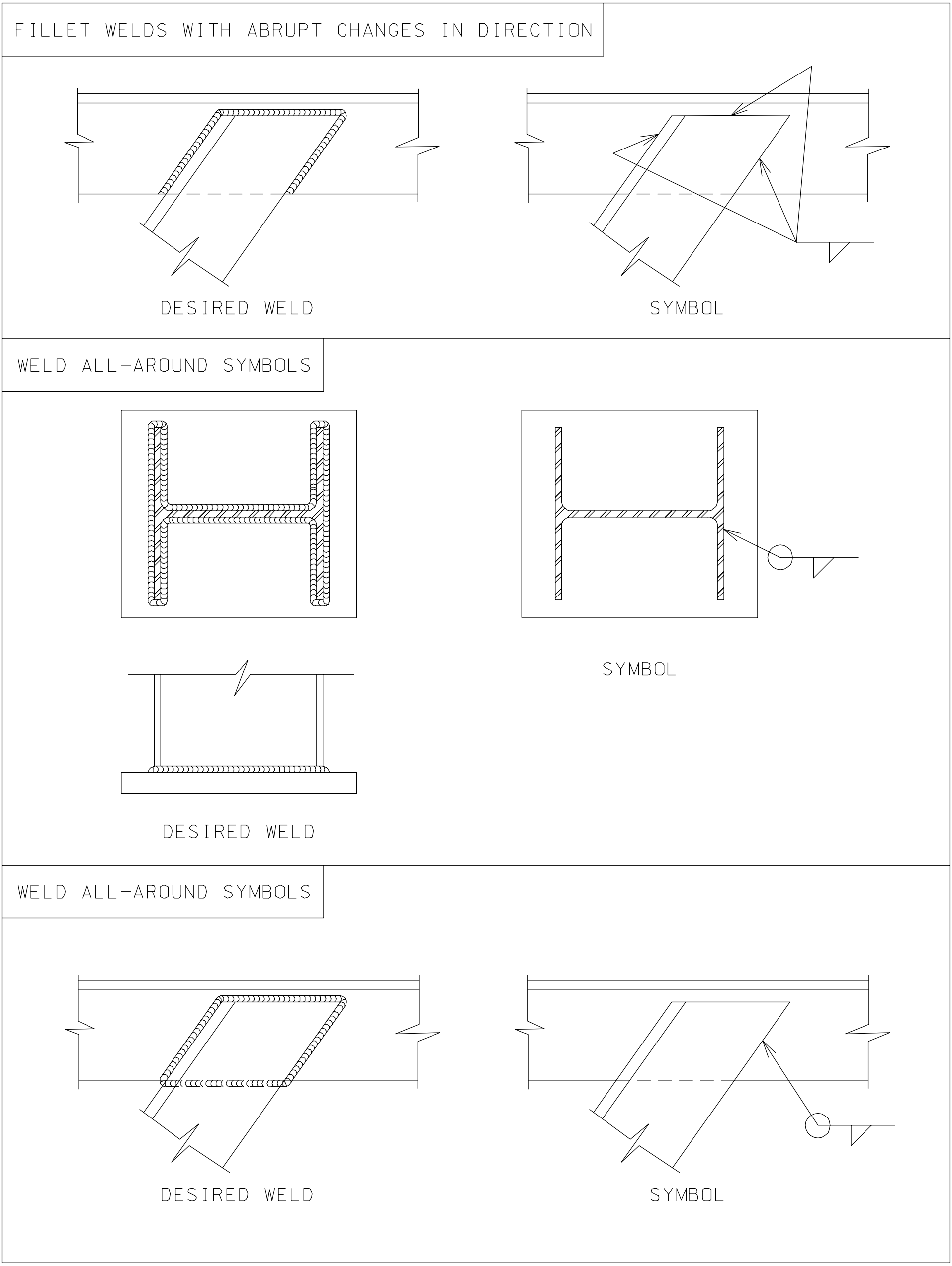
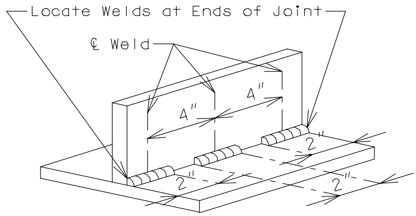
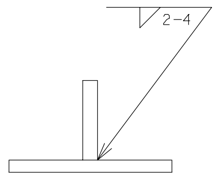


Figure 2.4.9-9 Application of Symbols - Fillet Welds

LENGTH AND PITCH OF INCREMENTS OF INTERMITTENT WELDING

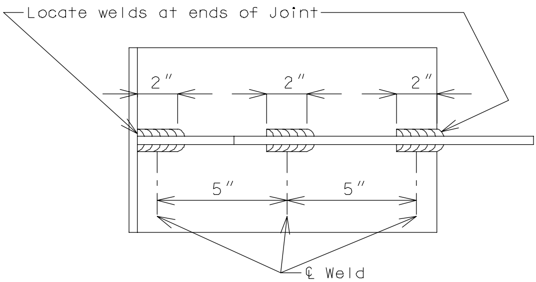


DESIRED FILLET WELDS

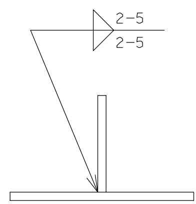


SYMBOL

LENGTH AND PITCH OF INCREMENTS OF CHAIN INTERMITTENT WELDING

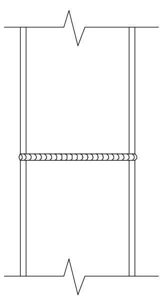


DESIRED FILLET WELDS

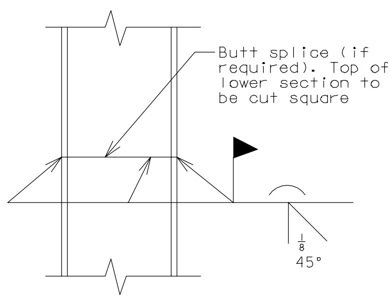


SYMBOL

DETAIL OF STEEL PILE SPLICE



WELD FOR SPLICING PILE



STEEL PILE SPLICE

Figure 2.4.9-10 Application of Symbols

2.4.10 Reinforcing Steel Detailing

General

Unless otherwise specified, reinforcement shall be Grade 60, deformed bar * meeting the requirement of AASHTO M31, AASHTO M42 or AASHTO M53. Details for dimensioning reinforcing steel shall be in accordance with the CRSI Manual of Standard Practice.

**** Except that plain bars or plain wire may be used for spirals, hoops and wire fabric.***

Reinforcement Sizes

For general use, reinforcement may range from #4 through #11 bars with restrictions as described for individual structural components. #14 and #18 bars shall not be used without the permission of the Structural Project Manager.

Reinforcement Length

Minimum length

Minimum reinforcement length shall be 2'-0" except for dowel bars and anchor bars.

Maximum length

Maximum reinforcement length shall be as follows:

Non Epoxy Coated Reinforcement	
#4 bars and larger	60'-0"
Epoxy Coated Reinforcement	
#4 bars and larger	60'-0"

Bar Length Calculation

Reinforcing bar lengths shall be calculated to the nearest 1/8" for individual dimensions and rounded to the nearest 1" for the nominal and actual lengths.

Use **Table 2.4.10.1**, **Table 2.4.10.2**, **Table 2.4.10.3** for figuring reinforcing bar lengths with stirrup hooks or end hooks.

LRFD 5.10.3

Reinforcement Spacing

Reinforcement spacing shall be in accordance with LRFD 5.10.3 unless modified by the following criteria or elsewhere shown in Bridge Manuals.

Minimum Spacing - Moment Reinforcement	
Preferred Min. - Footings	6" centers
Preferred Min. - Slabs	6" centers
Absolute Min. - Slabs	5” centers
Preferred Min. - All Other	4” centers
Absolute Min.	2-1/2” clear

Maximum Spacing - Moment Reinforcement

Absolute Max. - Slabs	1.5(slab thickness)
Absolute Max. - All Other	18"

Minimum Spacing - Shear Reinforcement

Absolute Min. - Substr. Beams	6" centers
Absolute Min. - P/S I Girder	5" centers

Maximum Spacing - Shear Reinforcement

LRFD 5.8.2.7

Absolute Max. - Substr. Beams	12" centers
Absolute Max. - P/S I Girder	Refer to LRFD DG Sec. 3.55

Minimum Spacing - Compression Reinforcement

Absolute Min.	4-1/2" centers
Absolute Min. - Cols. (thru #10)	2" clear
Absolute Min. - Cols. (#11, #14)	2-1/2" clear
Absolute Min. - Cols (#18)	3-1/2” clear

Maximum Spacing - Compression Reinforcement

Absolute Max. - the minimum number of longitudinal reinforcing bars shall be six for circular members and four for bars in a rectangular arrangement.

Maximum Spacing - Spiral Reinforcement for Compressive Members

Absolute Max. - Spirals 6” Centers

LRFD 5.10.6.3

Maximum spacing - Ties for Compression Reinforcement

Absolute Max. - Ties 12" centers

LRFD 5.12.3

Concrete Protection and Cover ***Min. Cover***

Conc. cast against and permanently exposed to earth……… 3"
Conc. exposed to earth or weather:
primary reinforcement……………………………………… 2"
stirrups, ties, spirals…………………………………….1-1/2"
Conc. slabs which have no positive corrosion protection:
top reinforcement………………………………………… 3" *
bottom reinforcement ……………………………………… 1"
Conc. not exposed to weather or in contract with ground:
primary reinforcement (thru #11) ………………………1-1/2"
stirrups, ties, spirals………………………………………. 1"
Conc. piles cast against or permanently exposed to earth… 2"
The minimum concrete cover = 1-1/2" clear for stirrup and tie steel unless otherwise specified.

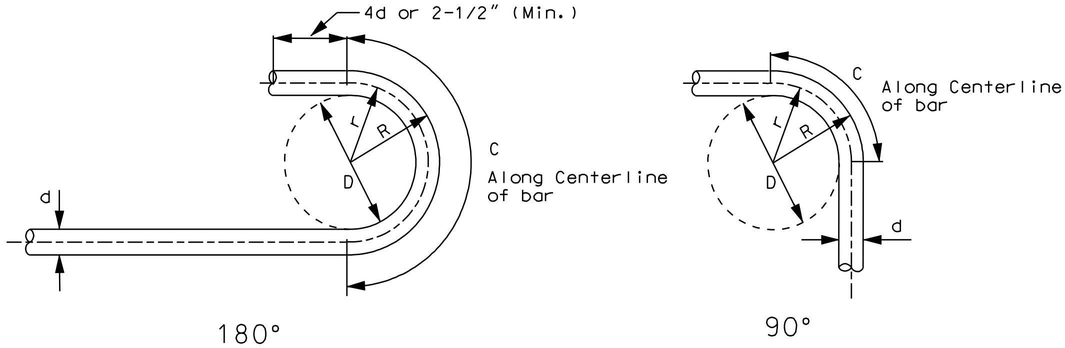
* ***Absolute minimum cover (2-1/2”) by LRFD 5.12.3***

Reinforcing Bar Supports

The height of all reinforcing bar supports shall be carried to the nearest 1/4". See Missouri Standard Plans Drawing 706.35 for details of bar supports.

Table 2.4.10.1 Table for Figuring Reinforcing Bar Lengths

Stirrup and Tie bars Hooks only



	d (d_b)	**D** **	**r**	**R**	**c (90°)**	**Deduct (90°)** *	**A or G (90°)** **
#3	3/8"	D=4d=1-1/2"	15/16"	1-1/8"	1-1/2"	3/4"	4"
#4	1/2"	D=4d=2"	1-1/4"	1-1/2"	2"	1"	4-1/2"
#5	5/8"	D=4d=2-1/2"	1-9/16"	1-7/8"	2-1/2"	1-1/4"	6"
#6	3/4"	D=6d=4-1/2"	2-5/8"	3"	4-1/8"	1-7/8"	12"

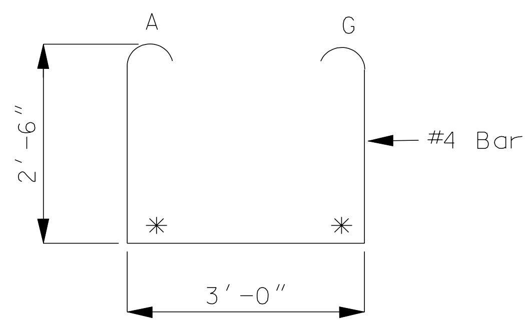
$d = d_b$ = Bar diameter
$r = D/2 + d/2$
$C(30°) = 2\pi r(30°/360°) = \pi r/6$
$C(45°) = 2\pi r(45°/360°) = \pi r/4$
$C(60°) = 2\pi r(60°/360°) = \pi r/3$
$C(90°) = 2\pi r(90°/360°) = \pi r/2$
Deduct (90°)* = 2R -C (90°)

D = Finish inside bend diameter
$R = r + d/2$
$C(120°) = 2\pi r(120°/360°) = 2\pi r/3$
$C(135°) = 2\pi r(135°/360°) = 3\pi r/4$
$C(150°) = 2\pi r(150°/360°) = 5\pi r/6$
$C(180°) = 2\pi r(180°/360°) = \pi r$
Deduct (180°)* = 4R -C (180°)

EXAMPLE:

#4 Stirrup with 2 - 90° bends

2 (2'-6") = 5'-0"
3'- 0" = 3'-0"
A + G +) 9" **
8'-9"
2(*) =2 (Deduct) = -) 2" (From Table)
Actual Length = 8' -7"



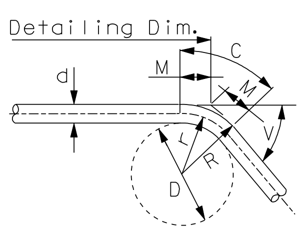
Note:
** Do not deduct * for a bend where A or G is taken from CRSI Manual of Standard Practice.*
*** See CRSI Manual of Standard Practice (January 1997) page 6-5.*

Table 2.4.10.2 Table for Figuring Reinforcing Bar Lengths (All Grades, End Hooks)

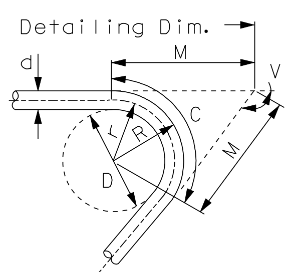
	End Hook		Angle (deg.) = 30°			Angle (deg.) = 45°			Angle (deg.) = 60°		
d	D	r	M(in.)	C(in.)	Deduct (in.)*	M(in.)	C(in.)	Deduct (in.)*	M(in.)	C(in.)	Deduct (in.)*
#3	2-1/4”	1-5/16”	3/8”	5/8”	1/8”	5/8”	1”	1/4”	7/8”	1-3/8”	3/8”
#4	3”	1-3/4”	9/16”	7/8”	1/8”	13/16”	1-3/8”	1/4”	1-1/8”	1-7/8”	1/2”
#5	3-3/4”	2-3/16”	11/16”	1-1/8”	1/4”	1-1/16”	1-3/4”	3/8”	1-7/16”	2-1/4”	5/8”
#6	4-1/2”	2-5/8”	13/16”	1-3/8”	1/4”	1-1/4”	2”	3/8”	1-3/4”	2-3/4”	3/4”
#7	5-1/4”	3-1/16”	15/16”	1-5/8”	1/4”	1-7/16”	2-3/8”	1/2”	2”	3-1/4”	7/8”
#8	6”	3-1/2”	1-1/16”	1-7/8”	1/4”	1-11/16”	2-3/4”	5/8”	2-5/16”	3-5/8”	1”
#9	9-1/2”	5-5/16”	1-9/16”	2-3/4”	3/8”	2-7/16”	4-1/8”	3/4”	3-3/8”	5-5/8”	1-1/4”
#10	10-3/4”	6”	1-3/4”	3-1/8”	3/8”	2-3/4”	4-3/4”	3/4”	3-13/16”	6-1/4”	1-3/8”
#11	12”	6-11/16”	2”	3-1/2”	1/2”	3-1/16”	5-1/4”	7/8”	4-1/4”	7”	1-1/2”

	Angle (deg.) = 90°			*Angle (deg.)* = 120°			*Angle (deg.)* = 135°		
d	M(in)	C(in)	Deduct (in.)*	R M (in.)	C	Deduct (in.)*	R M (in.)	C	Deduct (in.)*
#3	1-1/2”	2”	1”	2-5/8”	2-3/4”	2-1/2”	3-5/8”	3-1/8”	4-1/8”
#4	2”	2-3/4”	1-1/4”	3-7/16”	3-5/8”	3-1/4”	4-13/16”	4-1/8”	5-1/2”
#5	2-1/2”	3-3/8”	1-5/8”	4-5/16”	4-5/8”	4-1/8”	6-1/16”	5-1/8”	6-7/8”
#6	3”	4-1/8”	1-7/8”	5-3/16”	5-1/2”	4-7/8”	7-1/4”	6-1/8”	8-1/4”
#7	3-1/2”	4-3/4”	2-1/4”	6-1/16”	6-3/8”	5-3/4”	8-7/16”	7-1/4”	9-5/8”
#8	4”	5-1/2”	2-1/2”	6-15/16”	7-3/8”	6-1/2”	9-11/16”	8-1/4”	11-1/8”
#9	5-7/8”	8-3/8”	3-3/8”	10-3/16”	11-1/8”	9-1/4”	14-3/16”	12-1/2”	15-7/8”
#10	6-5/8”	9-1/2”	3-7/8”	11-1/2”	12-5/8”	10-3/8”	16-1/16”	14-1/8”	17-7/8”
#11	7-7/16”	10-1/2”	4-1/4”	12-13/16”	14”	11-5/8”	17-7/8”	15-3/4”	20”

	Angle (deg.) = 150°		
d	M(in.)	C(in.)	Deduct (in.)*
#3	5-5/8”	3-3/8”	7-3/4”
#4	7-1/16”	4-5/8”	10-3/8”
#5	9-5/16”	5-3/4”	12-7/8”
#6	11-3/16”	6-7/8”	15-1/2”
#7	13-1/16”	8”	18-1/8”
#8	14-15/16”	9-1/8”	20-3/4”
#9	21-15/16”	13-7/8”	30”
#10	24-13/16”	15-3/4”	33-7/8”
#11	27-5/8”	17-1/2”	37-3/4”



30° - 45° - 60°

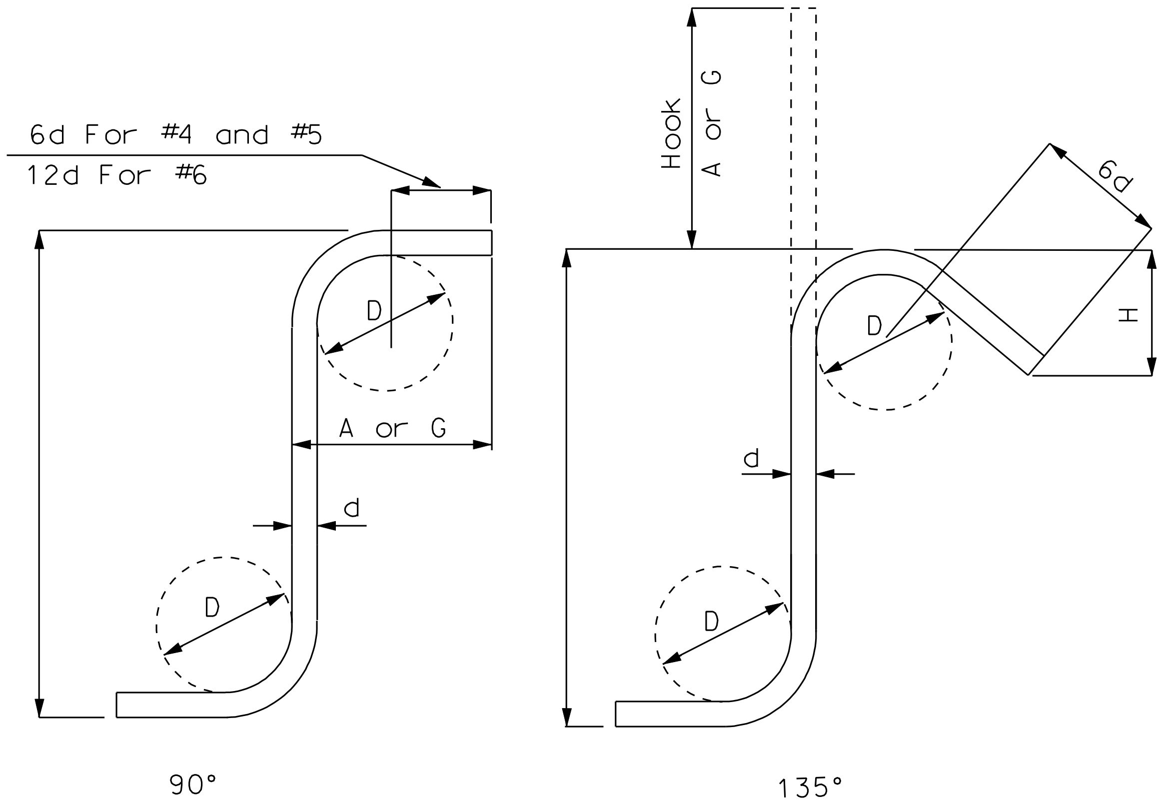


120° - 135° - 150°

C = Length along centerline of bar. D (#3 thru #8) = 6d, D(#9 thru #11) = 8d Above tables only.
Deduct (all above angles except 90°) * = 2M - C or Deduct (90° Only) * = 2R - C
M (all above angles except 90°) = R tan (∠/2) or M (90° Only) = R
For additional coding and information see preceding page.

**** Do not deduct * for a bend where A or G is taken from CRSI Manual of Standard Practice***

Table 2.4.10.3 Table for Figuring Reinforcing Bar Lengths (Stirrup Hooks)



STIRRUP HOOK DIMENSIONS *				
GRADE 40 - 50 - 60 ksi				
BAR SIZE	**D (inch)**	**90° Hook**	**135° Hook**	
		Hook A or G	**Hook A or G**	**Approx. H**
#4	2”	4-1/2”	4-1/2”	3”
#5	2-1/2”	6”	5-1/2”	3-3/4”
#6	4-1/2”	12”	8”	4-1/2”

** See CRSI Manual of Standard Practice .*

2.4.11 Development and Splicing of Reinforcement

11.1 General

Development of Tension Reinforcement

LRFD 5.11.2.1

Development lengths for tension reinforcement shall be calculated in accordance with LRFD 5.11.2.1. Development length modification factors described in second and third bulleted paragraphs of LRFD 5.11.2.1.3 shall only be used in situations where development length without these factors is difficult to attain. All other modification factors shown shall be used.

Development lengths for tension reinforcement have been tabulated on the following pages and include the modification factors except those described above.

Lap Splices of Tension Reinforcement

LRFD 5.11.5

Lap splices of reinforcement in tension shall be calculated in accordance with LRFD 5.11.5.2.1 and 5.11.5.3.1. Class C splices are preferred when possible, however it is permissible to use Class A or B when physical space is limited. The designer shall satisfy LRFD Table 5.11.5.3.1-1 when using Class A or B splices. It should be noted that "as required" is based on the stress encountered at the splice location, which is not necessarily the maximum stress used to design the reinforcement.

ACI 318R-89 7.12.2.3

Temperature and shrinkage reinforcement is assumed to fully develop the specified yield stresses. Therefore the development length shall not be reduced by (A_S required)/(A_S supplied).

Splice lengths for tension reinforcement have been tabulated on the following pages and include the development length modifications as described above.

Development of Tension Hooks

LRFD 5.11.2.4

Development of tension hooks shall be calculated in accordance with LRFD 5.11.2.4. Hook length modification factors described in the second and third bulleted paragraphs of LRFD 5.11.2.4.2 shall only be used in situations where hook length without these factors is difficult to attain. All other modification factors shown shall be used.

Development lengths of tension hooks have been tabulated on the following pages and include the modification factors except those described above.

Development of Compression Reinforcement

LRFD 5.11.2.2

Development lengths for compression reinforcement shall be calculated in accordance with LRFD 5.11.2.2. Development length modification factors described in LRFD 5.11.2.2.2 shall only be used in situations where development length without these factors is difficult to attain. All other modification factors shown shall be used.

Development lengths for compression reinforcement have been tabulated on the following pages and include the modification factors except those described above.

Lap Splices of Compression Reinforcement

LRFD 5.11.5

Lap splices of reinforcement in compression shall be calculated in accordance with LRFD 5.11.5.2.1 and 5.11.5.5.1.

Splice lengths for compression reinforcement have been tabulated on the following pages.

Mechanical Bar Splices

LRFD 5.11.5.2.2

Mechanical bar splices may be used in situations where it is not possible or feasible to use lap splices. Mechanical bar splices shall meet the criteria of LRFD 5.11.5.2.2. Refer to the manufacturers literature for more information on the design of mechanical bar splices.

11.2. Development and Tension Lap Splice Lengths – Top Bars (F_y = 60 ksi)

Step 1	Step 2	Step 3 fc	Step 4 Bars	Step 5 #3	#4	#5	#6	#7	#8	#9	#10	#11
< 6" on Center or < 3" clear cover (Dir. of Spacing ● ⟹)	NON-EPOXY	3 ksi	ℓ d	13	17	21	27	37	48	61	77	95
			B	17	22	28	35	48	63	79	101	123
			C	22	29	36	46	62	82	104	131	161
		4 ksi	ℓ d	13	17	21	26	32	42	53	67	82
			B	17	22	28	33	41	54	69	87	107
			C	22	29	36	43	54	71	90	114	140
	Epoxy 1 (<6d_b clear spacing OR < 3d_b cover (any direction)	3 ksi	ℓ d	16	21	26	33	45	59	74	94	115
			B	20	27	34	43	58	76	96	122	150
			C	27	35	44	56	76	99	126	159	196
		4 ksi	ℓ d	16	21	26	31	39	51	64	81	100
			B	20	27	34	40	50	66	83	106	130
			C	27	35	44	53	66	86	86	138	170
	Epoxy 2 (All Other Situations)	3 ksi	ℓ d	16	21	26	32	44	58	73	93	114
			B	20	27	33	42	57	75	95	121	148
			C	26	35	43	55	75	98	124	158	193
		4 ksi	ℓ d	16	21	26	31	38	50	63	80	99
			B	20	27	33	40	50	65	82	105	128
			C	26	36	43	52	65	85	108	137	168

Step 1	Step 2	Step 3 fc	Step 4 Bars	Step 5 #3	#4	#5	#6	#7	#8	#9	#10	#11
>= 6" on Center and >= 3" clear cover (Dir. of Spacing ● ⟹)	NON-EPOXY	3 ksi	ℓ d	12	14	17	22	30	39	49	62	76
			B	14	18	22	28	36	50	64	81	99
			C	18	23	29	37	50	66	83	105	129
		4 ksi	ℓ d	12	14	17	21	26	34	42	54	66
			B	14	18	22	27	33	44	55	70	86
			C	18	23	29	35	43	57	72	91	112
	Epoxy 1 (<6d_b clear spacing OR < 3d_b cover (any direction)	3 ksi	ℓ d	13	17	21	26	36	47	59	75	92
			B	16	22	27	34	46	61	77	98	120
			C	21	28	35	45	61	80	101	128	157
		4 ksi	ℓ d	13	17	21	25	31	41	51	65	80
			B	16	22	27	32	40	53	67	85	104
			C	21	28	35	42	53	69	87	111	136
	Epoxy 2 (All Other Situations)	3 ksi	ℓ d	13	17	21	26	35	46	59	74	91
			B	16	21	27	34	46	60	75	97	119
			C	21	28	35	44	60	75	99	126	155
		4 ksi	ℓ d	13	17	21	25	31	40	51	64	79
			B	16	21	27	32	40	52	66	84	103
			C	21	28	35	42	52	68	86	109	134

TOP BARS

Top bar is horizontal reinforcement placed so that more than 12" of fresh concrete is cast below the reinforcement.

Class A splice = 1.0 ℓd, Class B splice = 1.3 ℓd, Class C splice =1.7 ℓd

Use development and tension lap splices of f'_c = 4 ksi for concrete strengths greater than 4 ksi.

NOT TOP BARS

11.3. Development and Tension Lap Splice Lengths – Other Than Top Bars (F_y = 60 ksi)

Step 1	Step 2	Step 3	Step 4	Step 5								
		fc	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11
< 6" on Center or < 3" clear cover (Dir. of Spacing ● ⟹)	NON-EPOXY	3 ksi	ℓd	12	12	15	20	26	35	44	55	68
			B	12	16	20	25	34	45	57	72	88
			C	16	21	26	33	45	59	74	94	115
		4 ksi	ℓd	12	12	15	18	23	30	38	48	59
			B	12	16	20	24	30	39	49	62	77
			C	16	21	26	31	39	51	64	81	100
	Epoxy 1 (<6d_b clear spacing OR < 3d_b cover (any direction)	3 ksi	ℓd	14	18	23	29	39	52	65	83	102
			B	18	24	30	38	51	67	85	108	132
			C	23	31	39	49	67	88	111	141	173
		4 ksi	ℓd	14	18	23	27	34	45	57	72	88
			B	18	24	30	36	44	58	74	93	115
			C	23	31	39	46	58	76	96	122	150
	Epoxy 2 (All Other Situations)	3 ksi	ℓd	12	15	18	23	32	42	52	66	82
			B	15	19	24	30	41	54	68	86	106
			C	19	25	31	39	53	70	89	113	138
		4 ksi	ℓd	12	15	18	22	27	36	45	58	71
			B	15	19	24	29	36	47	59	75	92
			C	19	25	31	37	46	61	77	98	120

Step 1	Step 2	Step 3	Step 4	Step 5								
		fc	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11
>= 6" on Center and >= 3" clear cover (Dir. of Spacing ● ⟹)	NON-EPOXY	3 ksi	ℓd	12	12	12	16	21	28	35	44	55
			B	12	13	16	20	28	36	46	58	71
			C	13	17	21	26	36	47	59	75	92
		4 ksi	ℓd	12	12	12	15	18	24	30	39	47
			B	12	13	16	19	24	31	39	50	61
			C	13	17	21	25	31	41	51	65	80
	Epoxy 1 (<6d_b clear spacing OR < 3d_b cover (any direction)	3 ksi	ℓd	12	15	18	23	32	42	52	66	82
			B	15	19	24	30	41	54	68	86	106
			C	19	25	31	39	53	70	89	113	138
		4 ksi	ℓd	12	15	18	22	27	36	45	58	71
			B	15	19	24	29	36	47	59	75	92
			C	19	25	31	37	46	61	77	98	120
	Epoxy 2 (All Other Situations)	3 ksi	ℓd	12	12	15	19	25	33	42	53	65
			B	12	15	19	24	33	43	55	69	85
			C	15	20	25	32	43	56	71	90	111
		4 ksi	ℓd	12	12	15	18	22	29	36	46	57
			B	12	15	19	23	29	37	47	60	73
			C	15	20	25	30	37	49	62	78	96

Class A splice = 1.0 ℓd, Class B splice = 1.3 ℓd, Class C splice =1.7 ℓd
Use development and tension lap splices of f'_c = 4 ksi for concrete strengths greater than 4 ksi.

11.4 Development and Lap Splice Lengths - Bars in Compression (F_y = 60 ksi)

Step 1	Step 2	Step 3	Step 4	Step 5										
		fc	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14(2)	#18(2)
Compression	Development	3 ksi	ℓ_d	9	11	14	17	20	22	25	28	31	37	50
			$\ell_{d, Spiral}$[1]	8	9	11	13	15	17	19	21	24	28	37
		4 ksi	ℓ_d	8	10	12	15	17	19	22	24	27	32	43
			$\ell_{d, Spiral}$[1]	8	8	9	11	13	15	16	18	20	24	32
	Lap Splice	$f_c \geq$ 3ksi	Standard Lap	12	15	19	23	27	30	34	39	43	51	68
			With Ties[3]	12	13	16	19	22	25	29	32	36	43	57
			With Spirals	12	12	15	17	20	23	26	29	32	39	51

[1]Development length for bar with spirals, ℓd_{spiral}, should be used if reinforcement is enclosed in a spiral of not less than ¼" diameter and no more than 4" pitch. See LRFD 5.11.2.2 for special conditions.

[2]Lap splices for #14 and #18 bars are not permitted except as column to footing dowels.

[3]Lap splice length with ties should be used when the ties along the splice have an effective area not less than 0.15 percent of the product of the thickness of the compression times the tie spacing.

All values are for splices with the same size bars. For different size bars, use the higher value of either the development length of the larger bar or the splice length of the smaller bar.

11.5 Development of Standard Hooks in Tension, L_{dh} (F_y = 60 ksi)

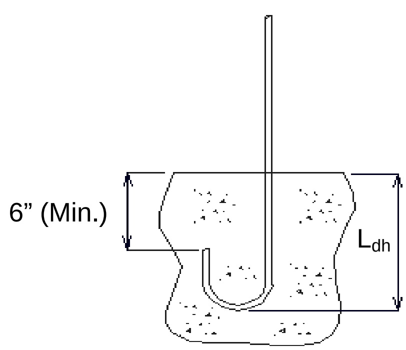
The development length, L_{dh}, is measured from the critical section to the outside edge of the hook. The tabulated values are valid for both epoxy and non-epoxy coated hooks.

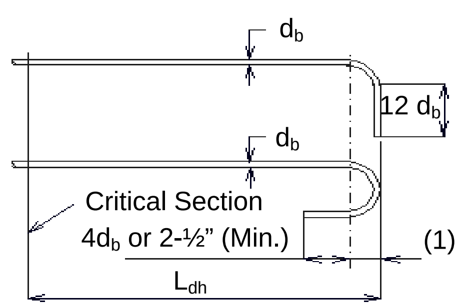
Step 1	Step 2	Step 3	Step 4	Step 5										
		fc	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14(2)	#18(2)
Hooks in Tension	Case A	3 ksi	Non-Epoxy	9	11	14	17	20	22	25	28	31	38	50
			Epoxy	10	14	17	20	24	27	30	34	38	45	60
		4 ksi	Non-Epoxy	8	10	12	15	17	19	22	25	27	33	43
			Epoxy	9	12	15	18	20	23	26	29	33	39	52
	Case B	3 ksi	Non-epoxy	6	8	10	12	14	16	18	20	22	38	50
			Epoxy	7	10	12	14	17	19	21	24	26	45	60
		4 ksi	Non-Epoxy	6	7	9	10	12	14	15	17	19	33	43
			Epoxy	6	8	10	12	14	16	19	21	23	39	52
	Min. L_{dh} for 6" (Min.) required at free edge or Const. Joint[2]			10	11	11	12	13	14	17	18	19	23	29

Case A - For #11 bar and smaller, side cover (normal to plane of hook) less than 2-1/2" and for a 90° hook with cover on the hook extension less than 2".

Case B - For #11 bar and smaller, side cover (normal to plane of hook) greater than 2-1/2" and for a 90° hook with cover on the hook extension 2" or greater.

(1) See Structural Project Manager before using #14 or #18 hook.
(2) When detailing near a free edge or construction joint, the larger development length value from the minimum L_{dh} category or the value from the applicable case given in the table shall govern





(1) = $4d_b$ (#3 thru #8)
(1) = $5d_b$ (#9, #10 and #11)
(1) = $6d_b$ (#14 and #18)

DETAILS NEAR FREE EDGE OR CONSTRUCTION JOINT

HOOKED-BAR DETAILS FOR DEVELOPMENT OF STANDARD HOOKS

11.6 Development of non-epoxy coated Grade 40 deformed bars in tension, L_d (LRFD 5.11.2.1)

Step 1	Step 2	Step 3	Step 4	Step 5										
		f'c	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
< 6" on Center or < 3" clear cover (Dir. Of Spacing ● ⇨)	NON-EPOXY	3 ksi	ℓd	12	12	12	13	18	23	29	37	46	63	81
			Top Bars	12	12	14	18	25	32	41	52	64	88	114
		4 ksi	ℓd	12	12	12	12	15	20	25	32	39	54	70
			Top Bars	12	12	14	17	21	28	35	45	55	76	98
		5 ksi	ld	12	12	12	12	14	18	23	29	35	49	63
			Top Bars	12	12	14	17	20	25	32	40	49	68	88

Step 1	Step 2	Step 3	Step 4	Step 5										
		f'c	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
>= 6" on Center or >= 3" clear cover (Dir. Of Spacing ● ⇨)	NON-EPOXY	3 ksi	ℓd	12	12	12	12	14	19	24	30	37	50	65
			Top Bars	12	12	12	15	20	26	33	42	51	70	91
		4 ksi	ℓd	12	12	12	12	12	16	20	26	32	44	56
			Top Bars	12	12	12	14	17	23	28	36	44	61	79
		5 ksi	ℓd	12	12	12	12	12	15	18	23	28	39	51
			Top Bars	12	12	12	14	16	20	26	32	40	55	71

Top bars are placed such that more than 12" of concrete is cast below the reinforcement.

11.7 Minimum lap length for non-epoxy coated Grade 40 tension lap splices, L_{lap} (LRFD 5.11.5)

Step 1	Step 2	Step 3: f'c	Step 4: Bars	Step 5: #3	#4	#5	#6	#7	#8	#9	#10	#11
< 6" on Center or < 3" clear cover (Dir. Of Spacing ● ⟹)	NON-EPOXY (Other than Top Bars)	3 ksi	A	12	12	12	13	18	23	29	37	46
			B	12	12	13	17	23	30	38	48	59
			C	12	14	17	22	30	39	50	63	77
		4 ksi	A	12	12	12	12	15	20	25	32	39
			B	12	12	13	16	20	26	33	42	51
			C	12	14	17	21	26	34	43	54	67
		5 ksi	A	12	12	12	12	14	18	23	29	35
			B	12	12	13	16	19	23	30	37	46
			C	12	14	17	21	24	31	39	49	60

Step 1	Step 2	f'c	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11
< 6" on Center or < 3" clear cover (Dir. Of Spacing ● ⟹)	NON-EPOXY (Top Bars)	3 ksi	A	12	12	14	18	25	32	41	52	64
			B	12	15	19	24	32	42	53	67	82
			C	15	20	24	31	42	55	69	88	108
		4 ksi	A	12	12	14	17	21	28	35	45	55
			B	12	15	19	22	28	36	46	58	71
			C	15	20	24	29	36	48	60	76	93
		5 ksi	A	12	12	14	17	20	25	32	40	49
			B	12	15	19	22	26	33	41	52	64
			C	15	20	24	29	34	43	54	68	84

Step 1	Step 2	Step 3: f'c	Step 4: Bars	Step 5: #3	#4	#5	#6	#7	#8	#9	#10	#11
>= 6" on Center or >= 3" clear cover (Dir. Of Spacing ● ⟹)	NON-EPOXY (Other than Top Bars)	3 ksi	A	12	12	12	12	14	19	24	30	37
			B	12	12	12	14	19	24	31	39	47
			C	12	12	14	18	24	32	40	50	62
		4 ksi	A	12	12	12	12	12	16	20	26	32
			B	12	12	12	13	16	21	26	34	41
			C	12	12	14	17	21	27	34	44	54
		5 ksi	A	12	12	12	12	12	15	18	23	28
			B	12	12	12	13	15	19	24	30	37
			C	12	12	14	17	20	25	31	39	48

Step 1	Step 2	f'c	Bars	#3	#4	#5	#6	#7	#8	#9	#10	#11
>= 6" on Center or >= 3" clear cover (Dir. Of Spacing ● ⟹)	NON-EPOXY (Top Bars)	3 ksi	A	12	12	12	15	20	26	33	42	51
			B	12	12	15	19	26	34	43	54	66
			C	12	16	20	25	33	44	55	70	86
		4 ksi	A	12	12	12	14	17	23	28	36	44
			B	12	12	15	18	22	29	37	47	57
			C	12	16	20	23	29	38	48	61	75
		5 ksi	A	12	12	12	14	16	20	26	32	40
			B	12	12	15	18	21	26	33	42	51
			C	12	16	20	23	27	34	43	55	67

Note: Design plan details shall indicate splice length.
Top bars are placed such that more than 12" of concrete is cast below the reinforcement

2.4.12 Miscellaneous

12.1 Negative Moment Steel over Intermediate Supports

See LRFD DG Sec. 3.30

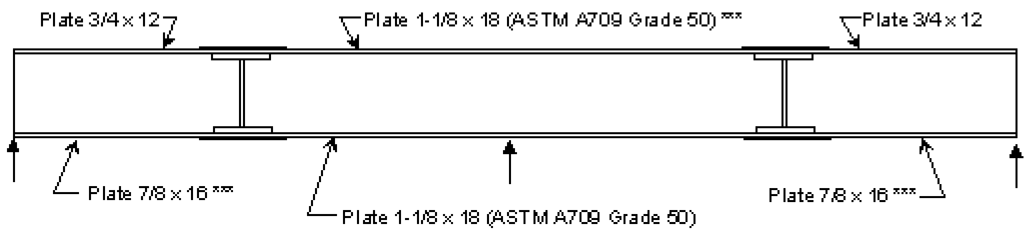
12.2 Notch Toughness

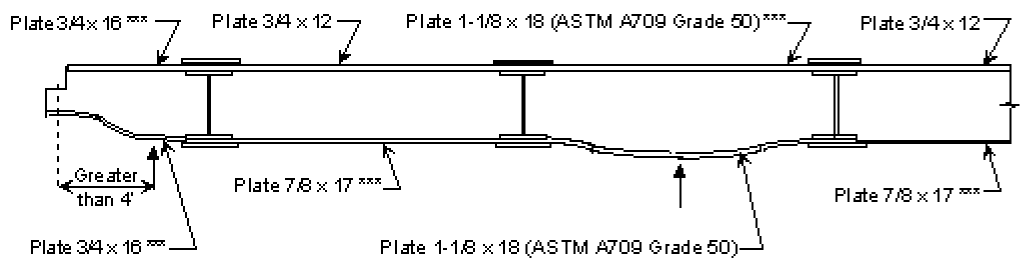
Wide Flange Beams Structures:

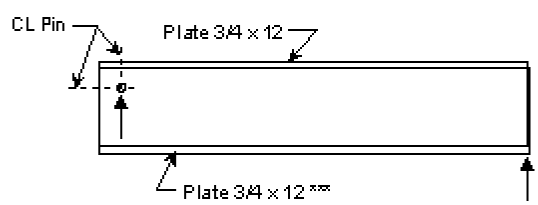
See LRFD DG Sec. 4.0.H1-C for proper notes to be placed on plans.

Plate Girders Structures:

See LRFD DG Sec. 4.0.H1-C for proper notes to be placed on plans. Typical examples for location of *** on plans for tension flange only of plate girders are shown below.







Note:
All web plates are subject to notch toughness.

Other special locations for *** will be for tension flanges of floor beams in straight girder bridges, and for top and bottom flanges of floor beams in curved girder bridges.

When any splices are located in a moment area, all flange and web splice plates for the bridge are subject to notch toughness requirements. Show *** with detail of flange splice plate

*12.3 Fracture Control Plan (FCP) **

Fracture Control Plan (FCP), Section 12 of ANSI/AASHTO/AWS D1.5-95, shall apply to fracture critical nonredundant member.

LRFD 1.3.4

Main elements and components whose failure is expected to cause the collapse of the bridge shall be designated as failure-critical and the associated structural system as non-redundant. Examples of nonredundant members are flange and web plates in one or two girder bridges, main one-element truss members and hanger plates.

LRFD 6.6.2

For non-redundant steel structures or members, the designer shall determine which, if any, component is a Fracture Critical Member (FCM). The location of all FCMs shall be clearly delineated on the design plans.

ANSI/AASHTO/AWS D1.5-95 12.2

FCMs are defined as tension members or tension components of bending members (including those subject to reversal of stress), the failure of which would be expected to result in collapse of the bridge. The designation "FCM" shall mean fracture critical member or member component. Members and components that are not subject to tension stress under any condition of live load are not fracture critical.
Any attachment welded to a tension zone of an FCM shall be considered an FCM when any dimension of the attachment exceeds 4 inches in the direction parallel to the calculated tensile stress in the FCM. Attachments designated FCM shall meet all requirements of FCP.
All welds to FCMs shall be considered fracture critical and shall conform to the requirements of FCP. Welds to compression members or compression area of bending member are not fracture critical.

LRFD 6.6.2

FCMs shall be fabricated in accordance with FCP. Material for FCM shall be tested in accordance with AASHTO T243 (ASTM A673), Frequency P. Material for components not designed as fracture critical shall be tested in conformance with AASHTO T243 (ASTM A673), Frequency H. The Sec 712 of the Standard Specification and FCM Special Provisions will include additional requirement for material, welding, inspection and manufacturing.

Notes to be placed on contract plans are as follows:
General Notes:

> This structure contains non-redundant Fracture Critical Members (F.C.M.). See Special Provisions for F.C.M. requirements.

Notes for Superstructure - Steel Spans

> (Place FCM next to the member or member components)

(Place following notes near the FCM)
FCM indicates Fracture Critical Member, see Special Provisions.
The welds for FCM's are controlled by ANSI/AASHTO/AWS D1.5-95.

The notes may replace the notch toughness requirement now being used. If there are components requiring notch toughness that are not FCM's on the same plans as FCM's both notes will be necessary.

** The designation "FCP" shall mean fracture control plan and shall include all provisions of Section 12 AASHTO/AWS Fracture Control Plan (FCP) for Nonredundant Members of ANSI/AASHTO/AWS D1.5-95, Bridge Welding Code.*

12.4 Decimal Equivalents Table

Decimals of a Foot for Inches and Fractions													
		0”	1”	2”	3”	4”	5”	6”	7”	8”	9”	10”	11”
0.0000”	0”	0.0000	0.0833	0.1667	0.2500	0.3333	0.4167	0.5000	0.5833	0.6667	0.7500	0.8333	0.9167
0.0625”	1/16”	0.0052	0.0885	0.1719	0.2552	0.3385	0.4219	0.5052	0.5885	0.6719	0.7552	0.8385	0.9219
0.1250”	1/8”	0.0104	0.0938	0.1771	0.2604	0.3438	0.4271	0.5104	0.5938	0.6771	0.7604	0.8438	0.9271
0.1875”	3/16”	0.0156	0.0990	0.1823	0.2656	0.3490	0.4323	0.5156	0.5990	0.6823	0.7656	0.8490	0.9323
0.2500”	1/4”	0.0208	0.1042	0.1875	0.2708	0.3542	0.4375	0.5208	0.6042	0.6875	0.7708	0.8542	0.9375
0.3125”	5/16”	0.0260	0.1094	0.1927	0.2760	0.3594	0.4427	0.5260	0.6094	0.6927	0.7760	0.8594	0.9427
0.3750”	3/8”	0.0313	0.1146	0.1979	0.2812	0.3646	0.4479	0.5313	0.6146	0.6979	0.7813	0.8646	0.9479
0.4375”	7/16”	0.0365	0.1198	0.2031	0.2865	0.3698	0.4531	0.5365	0.6198	0.7031	0.7865	0.8698	0.9531
0.5000”	1/2”	0.0417	0.1250	0.2083	0.2917	0.3750	0.4583	0.5417	0.6250	0.7083	0.7917	0.8750	0.9583
0.5625”	9/16”	0.0469	0.1302	0.2135	0.2969	0.3802	0.4635	0.5469	0.6302	0.7135	0.7969	0.8802	0.9635
0.6250”	5/8”	0.0521	0.1354	0.2188	0.3021	0.3854	0.4688	0.5521	0.6354	0.7188	0.8021	0.8854	0.9688
0.6875”	11/16”	0.0573	0.1406	0.2240	0.3073	0.3906	0.4740	0.5573	0.6406	0.7240	0.8073	0.8906	0.9740
0.7500”	3/4”	0.0625	0.1458	0.2292	0.3125	0.3958	0.4792	0.5625	0.6458	0.7292	0.8125	0.8958	0.9792
0.8125”	13/16”	0.0677	0.1510	0.2344	0.3177	0.4010	0.4844	0.5677	0.6510	0.7344	0.8177	0.9010	0.9844
0.8750”	7/8”	0.0729	0.1563	0.2396	0.3229	0.4063	0.4896	0.5729	0.6563	0.7396	0.8229	0.9063	0.9896
0.9375”	15/16”	0.0781	0.1615	0.2448	0.3281	0.4115	0.4948	0.5781	0.6615	0.7448	0.8281	0.9219	0.9948
		0”	1”	2”	3”	4”	5”	6”	7”	8”	9”	10”	11”

Example: 1/8" = 0.0104' (column 3, row 3)
1-1/2" = 0.1250' (column 4, row 9)
8-11/16" = 0.7240' (column 11, row 12)